Engineering News

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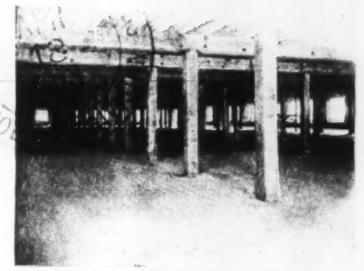

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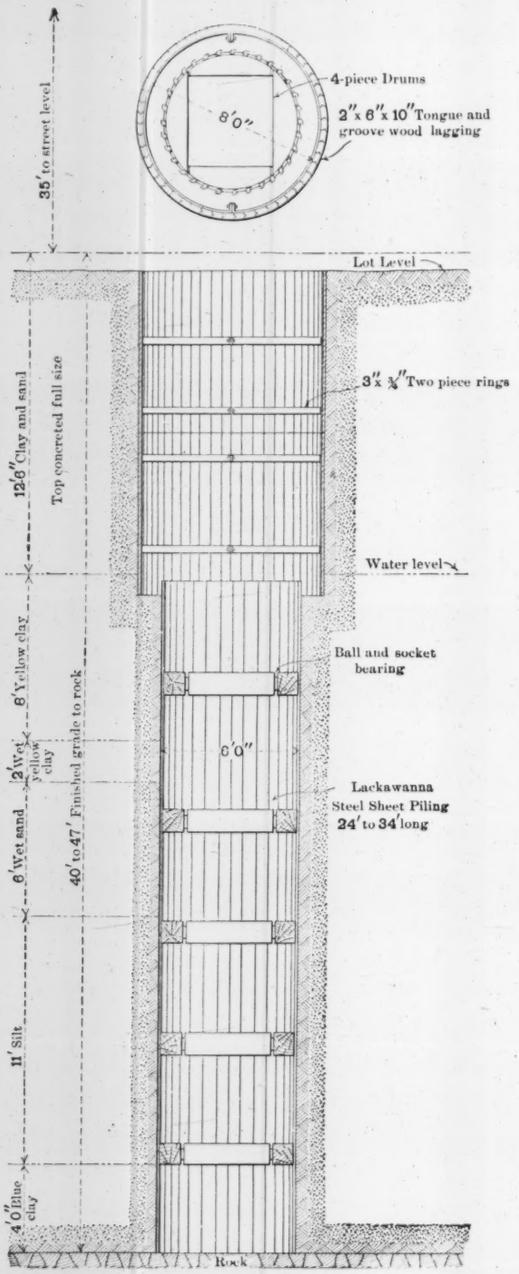

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Engineering News

CHARLES WHITING BAKER, *Editor*

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Many people do not believe in Advertising.

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Engineering News

VOLUME 69 JANUARY 30 1913 NUMBER 5

A Famous English Chain Suspension Bridge

A chain suspension bridge, which is of interest from its engineering features and its picturesque location, is the Clifton Bridge, which spans the River Avon, at Bristol, England. The river flows mainly through a rolling country, but at Clifton (a suburb of the city) it pierces a high rocky ridge by a gorge having vertical cliffs upon one side and steep wooded slopes on the other. The bridge is carried by chains composed of eye-bars. It has a span of 702 ft. 3 in. c. to c. of towers, and its floor is 245 ft. above high water; the height at low water is considerably greater, as the river has a phenomenal tidal range of 30 to 38 ft. The site is only a short distance below the entrance to the docks, and as there is a very sharp bend in the river, the channel has been widened, a roadway being cut in the solid rock on the west side, while on the east side a heavy retaining wall has been built, as shown beyond the large steamer in Fig. 1. There is a railway also on each side of the river, piercing the rocky points by tunnels as shown. Fig. 1 is a view of the bridge from the river, and shows how the steep slope at the right is terraced by means of heavy stone retaining walls. Fig. 2 is a view from the higher ground along the east end of the bridge.

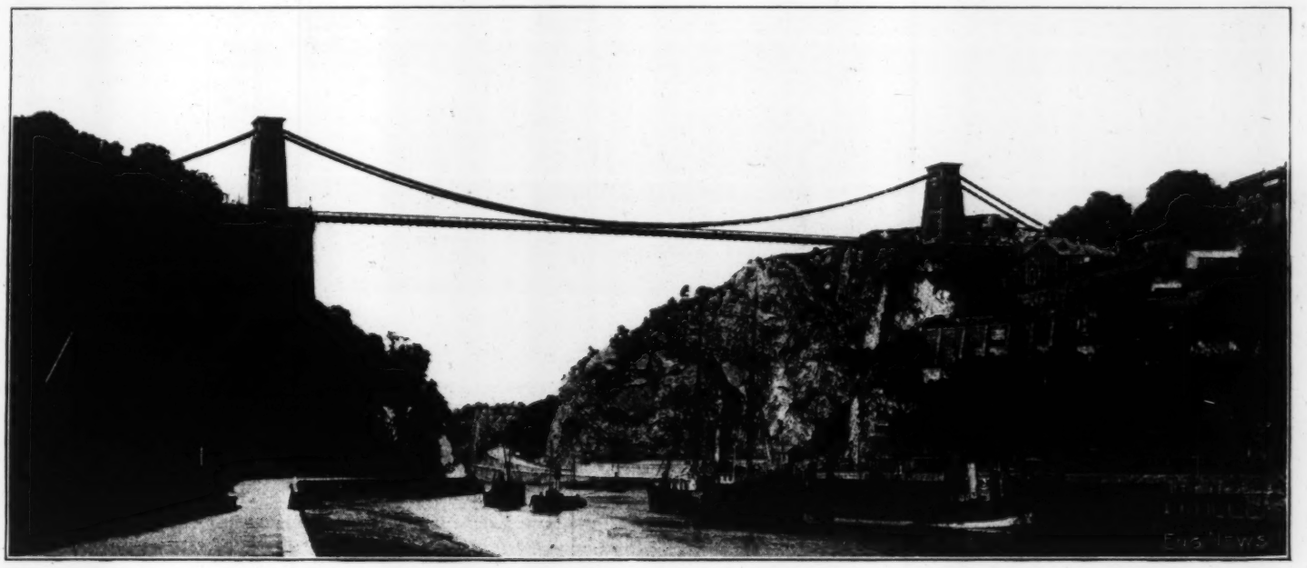

FIG. 1. THE CLIFTON SUSPENSION BRIDGE, OVER THE RIVER AVON, AT BRISTOL, ENGLAND
(Span, 702 ft. Height above high water, 245 ft.)

The idea of spanning the river at this point was conceived in the 18th century by an alderman named Vick, who by his will left $5000 toward the enterprise. This fund remained invested for some eighty years, when it had grown to about $40,000. Private and other subscriptions brought the amount up to $160,000, when actual construction was commenced. In 1829, designs for a suspension bridge were submitted by Isambard Kingdom Brunel, but these were not accepted. In 1813, however, another design of his was accepted. The first stone was cut with some ceremony by Lady Elton, in 1831, and the foundation stone for the first abutment was laid Aug. 27, 1836. A cable was stretched across the gorge Sept. 26, 1836, and venturesome people were hauled across in a basket suspended from the cable, a small fee being charged for the trip. The Clifton (or east) abutment is of no great size, but owing to the slope on the west side the Leigh (or west) abutment is a bold and striking mass of stone masonry, as may be seen from the accompanying views. This latter abutment was completed in 1840, and then the towers were built, but the work was abandoned in 1853, owing to lack of funds to undertake the superstructure.

The superstructure finally erected (and now in place) was not built for this site. By a curious coincidence it was the work of the same engineer, although he had nothing to do with its removal to Bristol, this being undertaken after his death. In 1842, Mr. Brunel had built the Hungerford suspension bridge over the River Thames, at London (Charing Cross), but in 1861 (two years after his death), it was decided to remove this to make way for a new structure. It was then suggested that it could be utilized at Bristol. In that year, the present Clifton Suspension Bridge Co. was formed, and purchased the chains and other work of the Hungerford bridge. The material was transported to Bristol and rëerected on the towers of the Clifton Bridge. Eight wire cables carried a platform upon which the chains were put to-

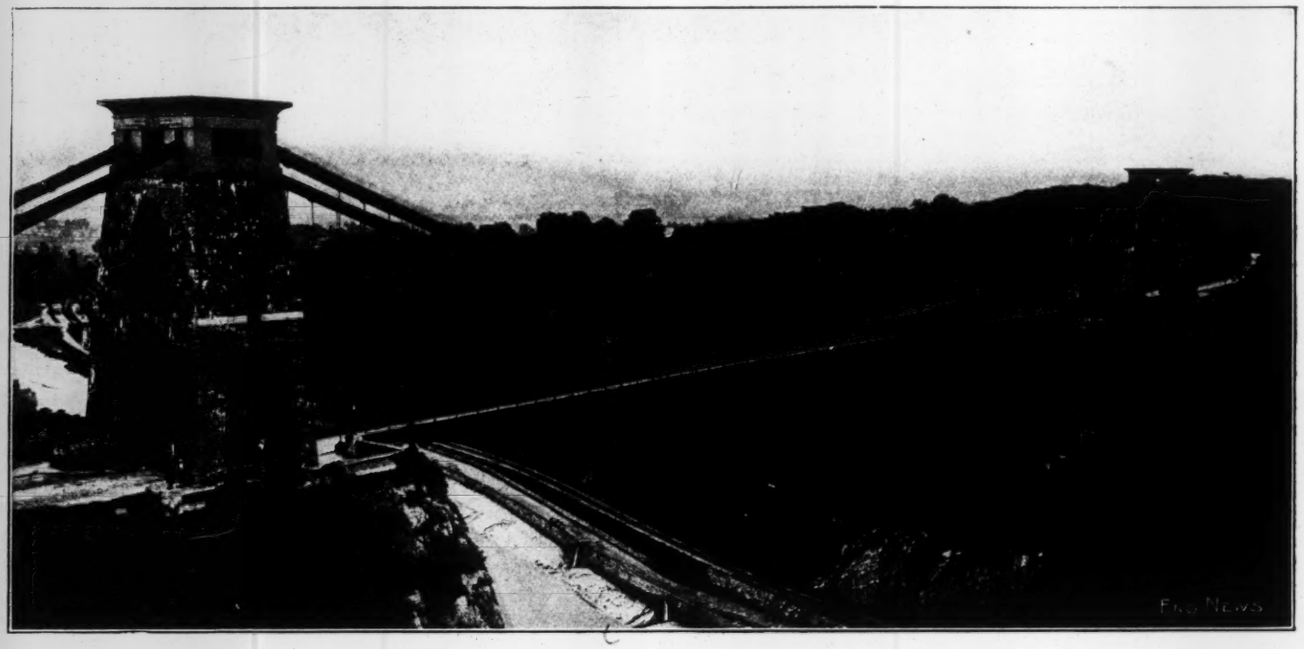

FIG. 2. THE CLIFTON SUSPENSION BRIDGE

gether, the bars being taken out by a car or platform suspended from another cable. This bridge was opened on Dec. 8, 1864. Its total cost was about $500,000.

The towers are of rough-faced gray granite, pierced with openings to reduce the weight, and having the corners beveled or chamfered. The towers have a decided curved taper to the upper part (which is of dressed stone and incloses the saddle chambers), and the whole appearance is very massive. The height of the towers above the abutments is about 70 ft. The chains are anchored 70 ft. deep in the solid rock. At about 200 ft. from the tower each chain passes over a fixed saddle bolted to the wall of the anchorage tunnel and then extends at an angle of 45° to the anchor plate and chamber.

The chains are composed of eye-bars packed side by side on pins, there being 4200 bars for the two chains. These bars are 1 in. thick, and 7 in. deep in the body. The length of the bars at the middle of the chains (where they are nearly horizontal) is 24 ft.; as the inclination of the chain increases, the length of bars is increased, so that the horizontal projected length is 24 ft. throughout. In effect, each of the two chains is composed of three separate chains, one above the other, and staggered so that the connecting pins have a uniform spacing of 8 ft., as shown by the sketch in Fig. 3. This is the spacing of the vertical suspension rods which are attached to the pins. There are 132 of these rods, 1⅜ in. diameter, and ranging in length from 3 ft. to 60 ft. Each bar is in two parts, the larger one being attached to the chain pin, and the shorter one to a pin fitted to pin-plates riveted to the top chord of the stiffening girder. The two parts have threaded ends and are connected by long threaded sleeves. The sectional area of the chains is about 440 sq.in. at the center of the span and 489 sq.in. at the piers.

The stiffening girders are wrought-iron plate girders 3 ft. deep, the upper part separating the roadway from the sidewalks. The transverse floor beams extend beyond the girders so as to support the sidewalks. Additional stiffness is afforded by lattice girders 57 in. deep, which serve as railings at the outer edges of the sidewalks. The width of the bridge is 31 ft., and the floor has a camber of 18 in. at the middle of the span. The total weight is between 1400 and 1500 tons. The heaviest load allowed for any vehicle crossing the bridge is 7 tons. For inspection and painting the floor system there is a box extending across the full width of the bridge and suspended from frames attached to trolleys with grooved wheels which ride on top of the hand-rails. There are no wind guys, and the bridge has been observed to swing as much as 18 in. in very stormy weather, such as in southeasterly gales.

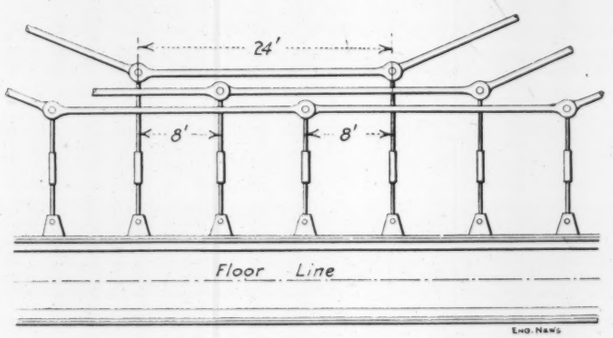

FIG. 3. ARRANGEMENT OF CHAINS AND SUSPENDERS ON THE CLIFTON BRIDGE

The designer and engineer of the bridge, Isambard Kingdom Brunel, was famous both as a railway engineer (notably for the construction of the Great Western Ry. system of 7-ft. gage) and as the designer of the famous early steamers, "Great Western," "Great Britain" and "Great Eastern," the first two of which sailed from the port of Bristol. He died in 1859. The present consulting engineer of the bridge company is H. Howard Humphrey, of London, and the resident inspector or engineer is Thomas Stevens.

British Opinion on Railway Automatic Stops

By H. Raynar Wilson*

The attention which the subject of automatic train control is again receiving in America, coupled with inquiries from America as to British experience in this direction, prompts the writer to review briefly the situation as it appears to one versed in the conditions in England and having some acquaintance with the altogether different situation to be faced in the United States.

Except on the electrically operated railways in London, automatic train control is not only absent from British railroads, but it has never been tried in regular work. There are reasons for this, but before giving them it should be noted that we have what we consider is the equivalent—locomotive cab-signals.

The repetition in the locomotive cab of the signals shown at the side of the track is a very old idea. In Great Britain cab-signals have always been advocated because of the frequency of fogs in the winter months, the density, inconvenience and danger of which can only be appreciated by those who have experienced them. Innumerable ideas have been submitted, and some tested, but all the earlier ones were abandoned for one cause or another. While many had mechanical defects, they all had one dangerous weakness—they failed to give "clear" indications as well as "danger"; the non-receipt of a "danger" signal, owing to the failure of some part of the apparatus, might lead to an engineer assuming that a "clear" fixed signal was turned, if only it could be seen.

Up to about seven years ago there was only one system that in any way approached the ideal. This was the apparatus designed by W. S. Boult whereby electrically actuated pointers were deflected to the right or to the left, thereby indicating "clear" or "danger," by means of induced currents picked up as the locomotive passed over certain magnetic fields which were varied to suit the condition of the fixed signals. This system, which was in actual work for some time on a leading English main line, gave other indications than these, but it is to be feared that the cost was too great. Probably, however, the characteristic objection of British railway officials to trying any new idea was principally against its further use. Anyway, Mr. Boult told the writer only a few weeks ago that he had dropped the subject.

Two other cab-signal systems have since been introduced and both are in actual work on main lines of railway. One of these, known as the "Audible," is in use on the Great Western Ry., and, experimentally, on the Midland. The other, called the "Raven," is to be found on the North Eastern Ry.

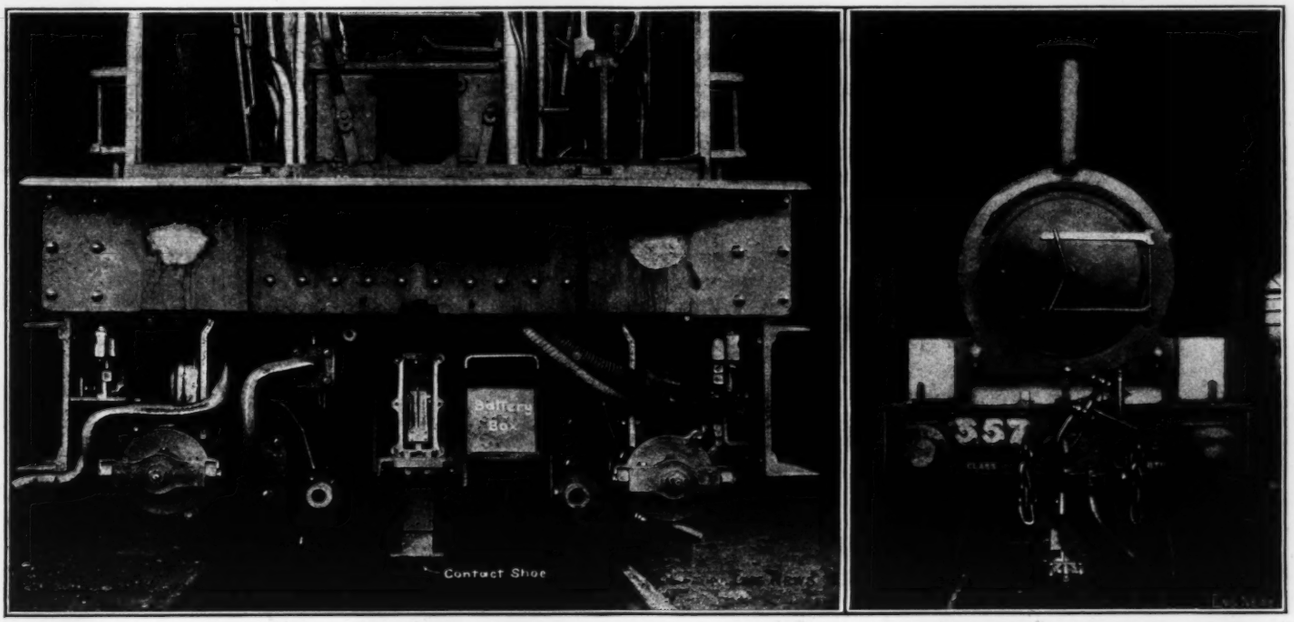

Fig. 1. "Audible" System Fig. 2. "Raven" System

Figs. 1 and 2. British Locomotive Cab-Signal Contact Shoes

The "Audible" system was described and illustrated on p. 36 of the first report of the United States Block Signal and Train Control Board; it was mentioned on p. 22 of the second report, and on p. 19 of the third, but a brief further description is desirable.* Fixed on the track at the advance ("distant") signal is a metallic ramp and on the engine is a corresponding shoe (Fig. 1) which, when lifted, opens a local circuit and causes a whistle to be blown. The ramp can be electrically connected to a battery in the signal-tower and is switched in by the lever that works the advance signal, or, if the latter is not provided, then by a special lever so interlocked that the stop ("home") signal for the same direction must have been "cleared" before the ramp is switched in. A diagram of the electrical connections is given in Fig. 3, from which it will be seen that if the ramp is "dead" the raising of the shoe causes a whistle to be blown. If, however, the ramp is in the cabin-battery circuit, the shoe picks up current which, through the

*96, Hurlingham Road, London, S. W. England.

*The earlier arrangements were described in Eng. News., May 2, 1907.—Ed.

relays, restrains the whistle and sounds a bell. A whistle therefore signifies "caution" and a bell indicates "clear." To guard against the ill-effects of frost there has been attached to the shoe a flexible pipe from the steam-heat supply. On the Great Western there are 35 engines fitted with the apparatus, seven of which have also an automatic brake application and there are 199 signaling ramps. On the Midland there are, I believe, two engines fitted and about a dozen ramps.

The "Raven" system was also mentioned in the first report of the U. S. Block Signal and Train Control Board, but not in respect to its present form. The whole Richmond branch track of the North Eastern Ry. and all the locomotives running thereon are equipped. This system also has on the locomotive a shoe (Fig. 2) which is raised by a ramp on the track but, different from the "Audible" system, there are at least three, and sometimes four or more, ramps. There is a bell, but no whistle. There is also a visual indicator, which is deflected when a "clear" signal is given and which is, in addition, made to show which way the switch is set when a junction is being approached. A normally dead ramp is placed, say, 450 ft. before an advance signal is reached. When the contact runs over this ramp (*A* in Fig. 4) the bell is started and it continues ringing until a second ramp is reached at the advance signal itself (Fig. 5, and *B* in Fig. 4). This ramp is electrically connected to the levers $H_1 H_2$ working the stop ("home") signals, and levers $A_1 A_2$ working the advance signals, which latter, in accordance with British practice, are placed in advance of the junction and allow the signalman to let a train, for which the line ahead is not clear, to get that much further on its road and yet be under the protection of the tower. Unless, then, both H_1 and A_1 are at "clear" for a train to proceed along line No. 1, or H_2 and A_2 at "clear" for No. 2 line, the second ramp is also dead. Whenever the shoe is raised by a ramp the bell stops ringing but, if the ramp is not connected the bell starts ringing again immediately the shoe falls as it leaves the ramp. If, however, the signals at the tower are at "clear," the ramp is connected and, when the shoe goes over, the main semaphore coils are energized, holding the bell and preventing its ringing even although the shoe has again fallen.

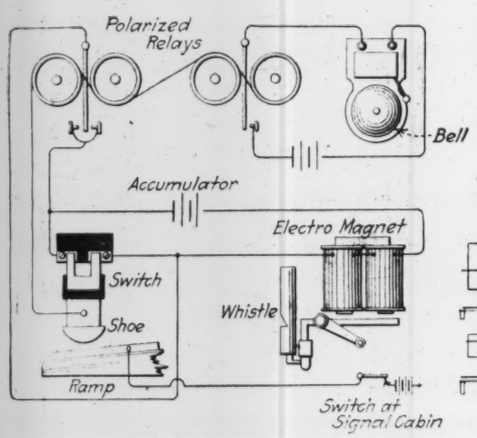

FIG. 3. DIAGRAM OF LOCOMOTIVE CIRCUITS; "AUDIBLE" CAB-SIGNAL SYSTEM

The engine driver, then, gets a warning, by means of the bell ringing at the first ramp, that he is approaching an advance signal and in 450 ft. or so, by the bell stopping, that he is at it. If the bell does not again sound he knows that the line is "clear," but if it resumes ringing it is an indication that the signals are against him and the man, therefore, gets his train under control, prepared to stop, on ramp *D*, at the stop signal. Between the ramp at the advance and that at the stop signal is an intermediate ramp *C* which is provided to intimate to an engine driver, who may be feeling his way in a dense fog, whether any change has been made since he passed the distant. The needle of the visual indication must be deflected when the bell does not resume ringing. When the engine gets to the final signal, the driver gets another ramp *E* or *E'*, according as to whether he is on No. 1 line or on No. 2. The line in the diagram, Fig. 4, runs from right to left and the signals point from the track.

These, then, are the only two cab-signals in use in Great Britain and, as they give every satisfaction, it is necessary to note why their use, or the use of some similar system, has not been extended. The main reason is that, owing principally to smoke-abatement legislation and the use of gas stoves and electricity, there has been much less fog during recent years. Moreover, the present system of fog-signaling by means of the sectionmen putting torpedoes on the rail when the signal is against a train, although antiquated and inconsistent (inconsistent in that a "clear" signal is given by the withdrawal of the torpedo) is well handled and it finds work for the sectionmen who would otherwise have to go home, as they are not allowed to work on the line during fog. Another factor is that it is almost essential that any cab-signal system should be universally adopted, if at all. The practice of running the trains of one company over the tracks of another is so widely in force that uniformity is almost vital. The engines of some English companies are ubiquitous. The Midland trains, for instance, travel on at least twenty other companies' lines. Consequently, if one company adopted cab-signal system A, and another had system B, and a third C, it is possible that some companies would have to have at least three systems fitted to their locomotives.

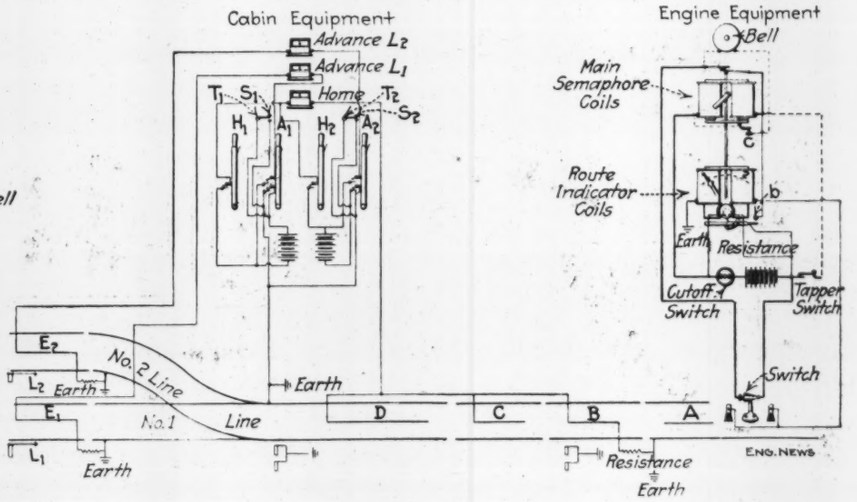

FIG. 4. LOCOMOTIVE AND TRACK CIRCUITS; "RAVEN" CAB-SIGNAL SYSTEM

So, for the present, British railways are simply "marking time" and awaiting events. In the meantime there is a growing fear among the officials, perhaps not yet pronounced, that something ought to be done in the way of fitting cab-signals to locomotives. But this is not so much for use during fog, but as an aid to the engineer in all weathers. There have been several cases where signals have been mis-read and a driver has taken the signals governing one track as applicable to him and ignored his own. Cab-signals in such a case would have warned him of his error. The writer has also recently advocated cab-signals for places where speed has to be reduced—not only at curves, drawbridges, etc., but also where there is a junction that allows for unlimited speed in one direction and restricted speed in the other. When

FIG. 5. ADVANCE-SIGNAL TRACK RAMP; "RAVEN" CAB-SIGNAL SYSTEM

the signals for the latter road were lowered, the cab-signal caution would be given; if the signals were adverse, the stop warning would be sounded in the usual way.

If, then, cab-signals have made such little progress in Great Britain, need it be wondered that automatic train control has made no progress? While there are few objections to cab-signals, there are numerous weighty ones against automatic control. There is, first, our comparative freedom from accident; secondly, the experience of the U. S. Block Signal and Train Control Board shows that a perfect system is hard to attain. Then, if it should be found there still are points that the Board has not yet dealt with, e. g., shall the controlling apparatus be at the distant or at the home signal; if at the latter, may not that be too late, and if at the distant, may not that be too soon? A third opposing factor, peculiar to Great Britain, is our light, unbraked freight wagon. Get a train of a hundred of these going down a steep grade and let the engine brakes be suddenly applied and there would be a wreck. Other objections might be named, but these are enough. Automatic train control is, therefore, unknown in Great Britain and likely to remain so.

In conclusion, the writer would like to suggest that instead of searching for a perfect control apparatus, American railroads might be satisfied to try a cab-signal. The conditions to be complied with are similar and many of the objections to automatic control are eliminated. I admit that a cab-signal will not pull up a train if the engine driver had fallen dead but, surely and fortunately, that is such a rare event that it need not enter into consideration. A cab-signal will awaken a man that is asleep, and pull together one dozing or with wits "wool-gathering," and under all conditions would be of great assistance to the engine driver. As applied on some parts of the Great Western Ry., distant signals are dispensed with and the engineman gets an intimation as to how the stop signal is by a ramp fixed the regulation distance out—about 2400 ft. from the stop signal.

The writer's experience in America has shown that the climatic conditions there, while very trying, can be overcome and that, instead of wasting time and energy in endeavoring to find a perfect automatic control, American railway companies would be wise to take the easier middle course and try a cab-signal to which, later, if necessary, train control could probably be added.

Fuller particulars of the "Audible" system may be obtained from Messrs. McKenzie & Holland, Ltd., 58 Victoria St., Westminster, London, S. W., and of the "Raven" system from Vincent L. Raven, chief mechanical engineer, North Eastern Ry., Darlington, England.

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The Public Service Commission of New York (First District), charged with supervision of utilities in New York City, in its sixth annual report presented to the legislature, on Jan. 13, gives the following figures, showing the amazing volume of earnings from the street traffic and lighting systems of New York City:

For the year 1911-12, the public in New York City paid for street-railway transportation $83,684,799. This is equivalent to about $16 per capita. For gas and electricity for a year the public paid $60,581,760—equal to about $12 per capita. This makes a grand total of $144,266,539 paid in the city of New York in one year for local transportation, gas and electricity.

The total number of passengers carried on street and electric railroads (including subways and elevated lines) was 1,680,914,025, an increase of 77,000,000 passengers over the preceding year, and an increase of 365,000,000 over the year 1907-08, the first year of the Commission. These railroads used 1666 miles of track and operated 11,688 passenger cars. More than 126 miles of track have been added during the life of the Commission.

The total capitalization, including capital stock and funded debts outstanding, of all companies subject to the jurisdiction of the Commission amounts to $1,104,993,683, of which $691,373,872 applies to street and electric railways, $210,952,600 to gas companies and $136,968,751 to electric light and power companies.

The number of gas consumers is 1,286,717, an increase of about 50,000 over the preceding year, and of 201,231 over the year 1908. The gas manufactured amounted to 43,297,216,000 cu.ft. In the same period the electricity generated amounted to 589,778,573 kilowatt-hours.

The Commission also has in charge the extension of the proposed transit subway system. The city of New York up to Dec. 31, 1912, had expended for rapid transit within the city $87,808,238. Of this total, $55,625,231 was spent upon the existing subway and $32,183,006 has so far been paid out under contracts for the construction of new subways for the dual system, namely, the Lexington Ave. and Centre St. loop subways, in Manhattan, and the Fourth Ave. subway, in Brooklyn.

It is estimated that the city will expend about $160,000,000, and the two companies between them about as much more in the construction and equipment of the dual system, the total expenditure being estimated at about $325,000,000. When completed the dual system will have three times the mileage of the existing li es.

The total construction work under contract on the subway system on Dec. 31, 1912, was $71,214,127.

Presidents of Four National Engineering Societies

For the 20th consecutive year we present to our readers portraits of the Presidents of the four great national engineering societies, and we print below biographies of each of them, prepared in each case by some personal friend who is himself a well known engineer.

It is noteworthy that this year three out of the four Presidents of the national engineering societies are engaged in the work of engineering education. This is the first time in its history that the American Society of Civil Engineers has chosen a Professor of engineering as its President. In the American Society of Mechanical Engineers the only other engineering professors elected to the Presidency have been its first President, the late R. H. Thurston of Cornell, elected in 1880, F. R. Hutton of Columbia, in 1907 and Alex. C. Humphreys of Stevens, elected last year.

In the Institute of Mining Engineers and of Electrical Engineers the number of past Presidents chosen from the ranks of the engineering professors is somewhat larger.

While Professors Swain and Goss and Kemp have each won enviable eminence for their work in engineering education, it is also true that the professional work of each outside of college walls has been of even greater importance in giving them the distinction which has resulted in their being honored with the highest office within the gift of their professional associates.

Geo. F. Swain, President of the American Society of Civil Engineers

By C. Frank Allen*

The American Society of Civil Engineers in choosing its President this year has, for the first time, elected a professor of engineering, for Professor Swain has attained, on the whole, greater distinction as an engineering educator than in the practice of his profession. His selection as President, however, would have been amply justified either by his standing as an engineer outside of his teaching work or because of his faithful and effective work within the Society.

George Fillmore Swain was born Mar. 2, 1857, in San Francisco. His ancestors, however, came from New England, and of these the Swains and Starbucks were among the best known families of Nantucket in its prime, when whale fishery not only bred sturdiness of character, but also brought prosperity with its many advantages. His father was a prominent citizen of San Francisco, and was one of its leading merchants. He served as President of the Chamber of Commerce, and was appointed Superintendent of the Branch Mint there during Lincoln's administration. His work at the Mint called for and developed a mathematical ability which was unusual and the son's success in this direction had some root both in inheritance and in example.

Young Swain received his preparation for college at a military school, and the effect of the discipline which goes with such a school may well have had an important influence in forming habits of mind and action which were elements in his later success. He became a student at the Massachusetts Institute of Technology at the early age of 16, led his class in scholarship and served as adjutant of the military battalion.

The thorough training characteristic of that institution in its turn could not do otherwise than serve to further develop the habits of thoroughness and of character already fairly established. Among the studies pursued there, the non-professional course in logic, taught at that time by Prof. George H. Howison, inspired in young Swain a taste for study along that line, and the reading done in this direction he has valued highly as an important part of his training. He also acquired a fondness for Shakespeare and this in connection with his logic certainly helped not only to clear thought, but habits of clear expression which a training in mathematics and science sometimes fails to secure.

His teacher in civil engineering was Prof. John B. Henck, a fine mathematician, a strict and clear teacher who demanded and received good work from his pupils and did more than any other member of the early faculty of "Tech" to fix the high standards of this institution. His influence on Professor Swain's later teaching must have been very great.

In 1877, Swain received his degree of "Bachelor of Science" in the course of "Civil and Topographical Engineering." Not satisfied with this, he spent three years abroad, primarily for the study of civil engineering, in which he did fine work, but with the added advantage to him of acquiring a breadth of view and experience in life, a wide acquaintance with men of various training, and an opportunity to travel, which together formed probably the most valuable feature of his life abroad, and which cannot be acquired from travel alone.

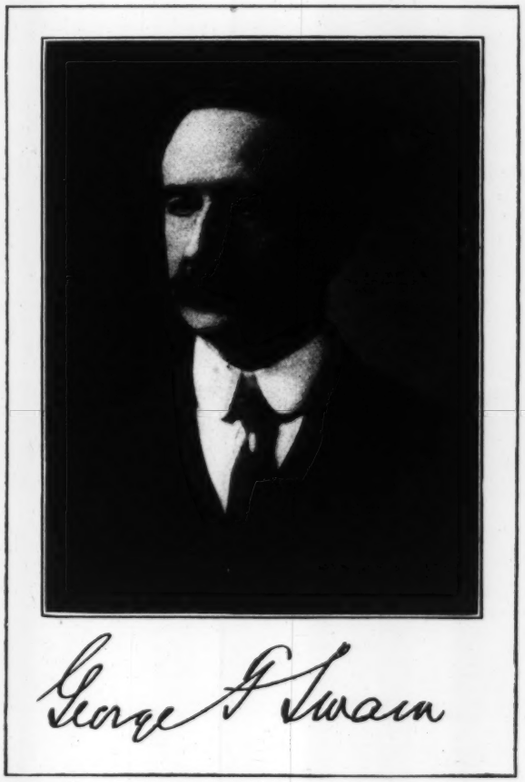
He studied at the Royal Polytechnicum at Berlin under such able masters as Winkler, Goering and Hagen, specializing in bridges and structures, railroads, and hydraulics, subjects valuable quite as much for training as for knowledge of the work covered. Advanced degrees there were then restricted to those who were to enter government service, so that he received no degree, but the substance he secured.

On his return to this country in 1880, he was employed as a special agent of the Census in investigating water power in connection with manufacturing interests, his field being the Atlantic slope. He also spent some time in hydraulic work in the Offices of Locks and Canals at Lowell, and of the Essex Co. at Lawrence.

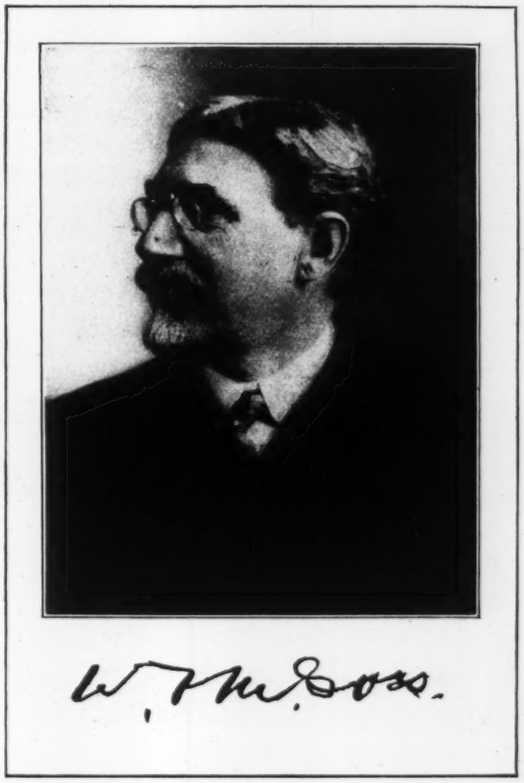
His water-power work was done under Gen. Francis A. Walker, Superintendent of the Census, who shortly afterward became President of the Massachusetts Institute of Technology. He promptly recognized Swain's ability by appointing him instructor in civil engineering. Early promotion followed to the position of assistant professor in 1883 and a few years later, in 1887, he became full professor in charge of the Department of Civil Engineering. Later the course in Sanitary Engineering, newly introduced, also came under his direction.

Although placed in charge of the Department of Civil Engineering at an early age (for conservative Boston), his success justified his appointment, and a remarkable development followed; when he became acting head of

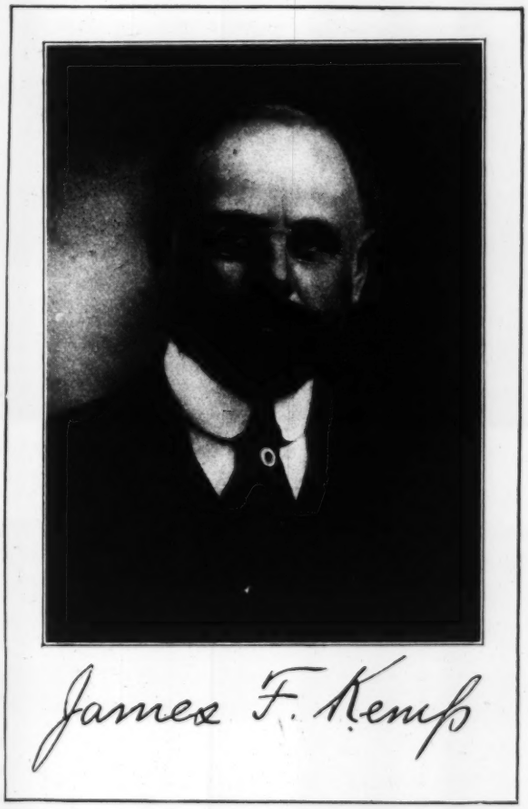
*Professor of Railroad Engineering, Massachusetts Institute of Technology, Boston, Mass.



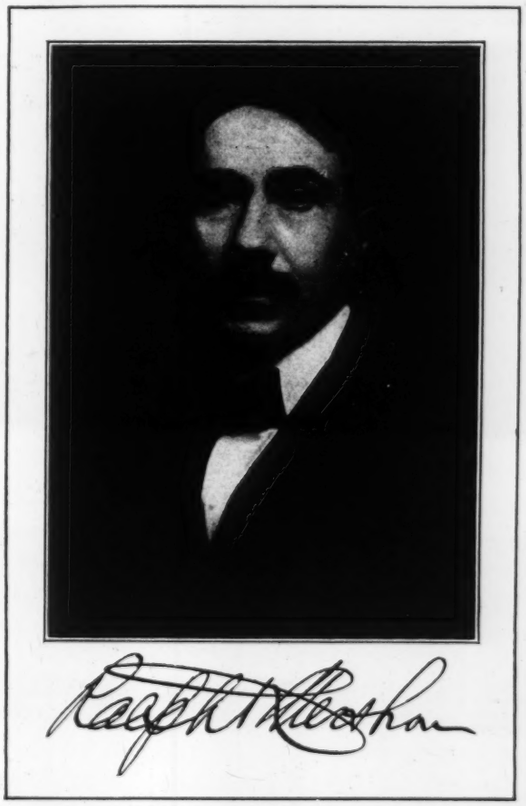
PRESIDENT OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS



PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS



PRESIDENT OF THE AMERICAN INSTITUTE OF MINING ENGINEERS



PRESIDENT OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

the department in 1887, he was the only full professor; there were three instructors and one assistant. In 1909 there were in the department twenty all told; ten of these were members of the faculty. In 1887 there was no department library worthy of the name; in 1909 it had become probably the best working library of civil engineering in the country, and it was due to his enthusiasm and judgment that this was accomplished.

While at Technology he served for a time as secretary of the Society of Arts, connected with it, and was also for two years secretary of the Technology Alumni Association.

In 1909, Prof. Swain was offered and accepted the Gordon McKay Professorship of Civil Engineering in the Graduate School of Applied Science, Harvard University. An important consideration in his acceptance was his expressed belief that this graduate school marked an advance in the status of engineering, putting it on the same basis as law and medicine, the schools of which for some time had been on a graduate basis at Harvard.

As a teacher, his standards have been high. He has demanded from his students not only diligence and attention, but beyond that has insisted upon clear thinking on their part. His work has been very thorough, of a high grade, and enforced by a steady drill in the principles of the subject. Here acquirement or an understanding of the subject in hand has been secondary to clear thinking along the line of work. He taught many subjects at the Institute in the early days, the important course in hydraulics being for several years in his charge. Later he confined his attention almost exclusively to structures, which he taught not only to undergraduate students, but also to the graduates, and he is best known in connection with this line of work.

In 1893, men engaged in teaching engineering in the United States and Canada organized the Society for the Promotion of Engineering Education. Prof. Swain was the second President of this Society, in which he took for many years an active part. His attitude toward the work of teaching was well defined in his presidential address on "The Profession of Engineering Teaching," in which he called attention to the necessity that professors of engineering should cultivate the teaching side, however attractive the engineering side may be. His reputation among the teachers of this country has placed him in the first rank.

He has been for a number of years one of the Board of Judges to select names for the Hall of Fame of New York University, and this university, in 1906, conferred upon him the honorary degree of LL.D. In 1908 he was appointed by President Roosevelt a member of the Inland Waterways Commission, and also of the Conservation Commission. This followed the hearings of a Congressional Committee upon the proposed Appalachian Forest Reserve, at which Prof. Swain took an important part.

His publications include notes on "Hydraulics" and also on "Structures" for the use of his classes, which have not been given general circulation. The *Journal* of the Franklin Institute for 1883 contains articles from him on "Mohr's Graphical Theory of Earth Pressures" and on the "Applications of Virtual Velocities to the Determination of the Deflection and Stresses of Frames"; in 1887 he contributed a paper to the American Society of Civil Engineers on the "Calculation of Stresses in Bridges for Concentrated Loads," a feature of which was the use of "Influence Lines." The two last mentioned papers have had a very material effect upon present practice in structural computations and investigations. He has been active in contributing to various society papers, and many official reports have been made by him, sometimes individually, sometimes as one of a board.

As an engineer, and as an official in connection with engineering work, he has had a large and successful experience. His first opportunity came in 1887, at the time of the failure of the Bussey Bridge, near Forest Hills, Boston. At the investigation which followed, the quality of his training and his ability to analyze the causes of the accident so impressed the Railroad Commission that he was appointed the first expert engineer of the Commission under a law newly passed, an office which he has continuously and satisfactorily filled and now holds; an office for which he is well fitted and which has yielded him a rare experience. The necessary changes and reforms in railroad-bridge practice in the state were secured quietly and with avoidance of ostentatious publicity.

In 1894, the Boston Transit Commission was organized to construct the Boston subways; Prof. Swain was one of the first commissioners appointed, and is now the sole remaining member of the original board. The work was without precedent in this country, was well carried out, and within the original estimates. The tunnel under Boston Harbor to East Boston was a part of the work of this Commission, as was also the Charlestown Bridge. At the present time the expenditure under this Commission has been in excess of $18,000,000.

In connection with architectural construction, he was employed upon the large extension of the State House at Boston, and upon many other works, some of which offered unusual problems. He has been consulting and designing engineer for a number of bridges, movable as well as fixed, an unusual case being the reconstruction of the old chain suspension bridge at Newburyport as a stiffened cable suspension bridge with a hinge at the center, and with reinforced-concrete towers.

He has served upon a number of Commissions to fix the method of eliminating grade crossings of highways with steam railroads, those at Worcester, Taunton, Newton and Waltham being among the most important. He was a member of the Commission to revise the building laws of Boston. He has also frequently been called upon as an expert in court cases, not only in Massachusetts, but elsewhere.

Quite recently Prof. Swain served as expert for the Commission on validation of the assets and liabilities of the New York, New Haven & Hartford R.R. This involved appraisals of properties and securities held by the railroads, a physical valuation, a consideration of economic problems, and a critical examination of books. This has been followed by similar valuations of other roads, both large and small. As late as 1912 he served the Chicago Elevated Railways as their expert in a valuation of their properties. Altogether these valuations sum up to many hundreds of millions of dollars.

He has been a member of many engineering societies, among them the Boston Society of Civil Engineers, of which he has been President; the American Society of Mechanical Engineers, the Institution of Civil Engi-

neers of Great Britain, the Canadian Society of Civil Engineers, the Society of Engineers of Hannover, Germany, the American Railway Engineering Association, the American Society for Testing Materials, the New England Water-Works Association, the New England Railroad Club, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science, of which he has been a Vice-President.

He has long been a pronounced believer in the advantage to engineers of associating more largely with business and professional men not engineers. His presidential address to the Boston Society of Engineers dealt with this subject; and consistently he is a member in Boston of the Union Club, a general social organization; the St. Botolph Club, where literary or similar qualification is necessary; and the Commercial Club, whose name indicates its business character.

Prof. Swain has a fine library, is fond of reading along varied lines, and reads German and French freely, not only for engineering purposes, but for their literature. He has been twice married, first to Katherine K. Wheeler, and second to Mary H. Lord, of Salem, who is pleasantly known to many members of the Society.

His success may be attributed in part to inherited ability and fine environment, at home and at school, both here and abroad; a training extended beyond that secured by most of his fellows; an orderly habit in his work and economy of effort, avoiding waste; a faculty for clear thought and clear expression; a remarkable capacity for hard, rapid and concentrated work, together with an appreciation of short cuts and effective methods.

Prof. Swain long since remarked that activity in the Society should precede rather than follow election to office. By his own standard, he qualifies well. Aside from papers and discussions in 1893, he translated from the German a paper for the Society on "Railway Signaling"; he was, back in 1887, a member of the Committee on Compressive Strength of Cements, was Chairman for some time of the Committee on Tests of Cements dating from 1897, and was also a member of the Committee on Columns appointed after the failure of the Quebec Bridge. Some of this committee work combined well with similar committee work of the Committee on Cement of the Society for the Testing of Materials, and the Committee on Masonry of the American Railway Association. He has served as a Director of the American Society of Civil Engineers, and later as its Vice-President, and has been an influential member of the board of government. He made a most excellent presiding officer for the Boston Society of Civil Engineers, and for the Society for the Promotion of Engineering Education, and he is therefore, by experience and natural qualifications, unusually well qualified to assume the duties of President of the American Society of Civil Engineers.

Timber for the Fenders of the Panama Canal approach walls to the locks, which were described in our issue of Nov. 2, 1911, has arrived on the Isthmus, and will be treated with preservative before it is installed. In all 551,312 ft. b. m., in sticks 12x16 in., and 16 ft. long, will be required, and the first shipment is about 200,000 ft. At the time the designs were made it was the intention to use oak for this purpose, but the cost of both oak and yellow pine was so great that bids were asked including Douglas fir. This wood has been selected at a price of $34.30 a thousand board feet. The climate and insects in Panama are very destructive to wood, so it will be treated with a preservative.

W. F. M. Goss, President of the American Society of Mechanical Engineers

By G. M. Basford*

In electing Dr. W. F. M. Goss as its President, the American Society of Mechanical Engineers honors him, but also brings honor to itself because of his accomplishments in engineering.

Dr. Goss was born in Barnstable, Mass., in 1859. At the Massachusetts Institute of Technology, in 1877, he entered the then recently established mechanic arts course, and two years later began the development of a similar course in mechanic arts at Purdue University, Lafayette, Ind. He began with a class of five students. For ten years he was occupied in building up this course and in preparing for a larger development at Purdue. As Professor of Practical Mechanics he became an important factor in influencing the introduction of new methods in technical education throughout the middle West. This was pioneer work in a period when a Professor of Practical Mechanics could exert great influence over thought in the educational world. When he began there was no college west of the Allegheny Mountains giving systematic courses in shop practice. From this small beginning, Dr. Goss developed the reputation of Purdue as a school of engineering, to a point which gave the university and himself an international reputation. He approached the education of engineers as a modern problem, which to a large extent explains his great success.

The lesson of Goss and Purdue is an important one for engineering educators to learn. His achievement at Purdue with what seem to have been entirely inadequate resources is certainly a most remarkable one. What he lacked at first in facilities he more than made up by the definiteness of his methods. Then he acquired the desired facilities and used them effectively.

He has always had the confidence of many men in high positions in engineering, manufacturing and transportation fields. This confidence was based upon his personality, his ability and his sound judgment. Thus he established and maintained close contact with problems of engineers. His opinions and advice are sought in many phases of engineering development, particularly in railroad lines. It is given to few educators to stand as close to leading men in his field of endeavor as Dr. Goss does to the railroad men. They claim him as their own.

In building up his educational methods he used research work most effectively. While his efforts were well balanced, the most important results were obtained through investigations concerning the locomotive and other railroad problems. The confidence and high esteem in which he is held by railroad officials is indicated by the location at Purdue of the official experimental testing equipment of the Master Car Builders' Association.

Until the building at Purdue of the first stationary locomotive-testing plant, all data upon the performance of the locomotive had been taken in road service and were of very limited value, really of no scientific value. This was because in road service it is impossible to obtain uniform or stable conditions, and such conditions are essential in scientific research. By use of this testing

*Assistant to President, American Locomotive Co., 30 Church St., New York City.

plant from which data could be taken from a locomotive as from a stationary-engine plant, with well trained assistants and his students, he brought out facts which were of great value and which began the development of scientific knowledge of the locomotive, resulting in changing the problem of locomotive design from one based upon judgment and experience, to one based upon scientific principles. The valuable work now being done on the Altoona testing plant of the Pennsylvania R.R., and that done by other progressive students of the locomotive would undoubtedly have been greatly delayed if Goss had not built his Purdue testing plant when he did.

From the Purdue plant came the first exact data concerning relation between combustion and grate areas of locomotives, concerning the capacity of the locomotive boiler at varying rates of combustion, the dynamic effect of counter-balance weights, the relative values of high- and low-steam pressures, the effectiveness and economy of superheated steam, and many other important subjects. The researches in high-steam pressures and superheated steam were conducted for the Carnegie Institution of Washington, and the results were published by the Institution.

The *Proceedings* of the American Society of Mechanical Engineers, of which Dr. Goss has been a member for many years; the records of the Master Mechanics' and Master Car Builders' Associations, and other railroad organizations, contain reports of his research work which in themselves constitute a great achievement. His best known books are those on "Locomotive Performance" and "Locomotive Sparks."

Dr. Goss does not end his research with the experiments themselves, but combines conscientious, thorough investigation with a remarkably clear-minded, judicial study of the results and conservative judgment as to their exact value and usefulness. He has a rare faculty of sorting out from a bewildering maze of figures those which lead to practical conclusions, and he always puts the results of his work in concise and perfectly definite form for engineers to use.

His observations of European engineering development, resulting from several extended trips abroad, are exceedingly important from an engineering standpoint, which renders them all the more valuable from an educational standpoint.

In 1888 he was given the degree of Master of Arts by Wabash College, and in 1904 he was honored with the degree of Doctor of Engineering by the University of Illinois. He was further honored by appointment on the National Advisory Board on Fuels and Structural Materials and was a member of the Jury of Awards in the Transportation Department of the World's Fair at Chicago.

In 1907 he was appointed Dean of the College of Engineering of the University of Illinois and made a member of the council of that university, charged with the administration of university affairs. For about twenty years he had been engaged in the development of advanced engineering work at Purdue, and he is now contributing to a further development in the same direction in a larger field. To him is intrusted the problem of bringing the College of Engineering up to its place in the high standard which has been set by the University of Illinois for its future development.

He undertakes this as in itself an engineering problem. He desires his professors to be the highest authorities in their various fields, believing that, if their opinions and advice are sought for by men of affairs, they will be the better teachers. He is making great progress in this direction. As a side light on his plans and the support he receives, he has doubled the salary account of the College of Engineering in five years. He is building up a strong teaching staff. He has plans on a large scale for activities of the engineering experiment station of the University and for the dissemination of engineering information.

His work has always been largely a personal one in that he has not been unduly bound by traditions or precedent, and he has been singularly free from fear of criticism. Few men have had as large a share in the progress of technical education as he has had, and few have made as strong an impress upon it. He is far sighted, enthusiastic and keenly alive to the demands which may reasonably be made upon the college and to its opportunities for service and advancement. Those characteristics which make him successful as an educator and administrator promise a successful, progressive administration as President of the American Society of Mechanical Engineers.

James Furman Kemp, President, American Institute of Mining Engineers

By Frank D. Adams*

There is probably no one who is more widely known among the mining fraternity of the North American continent than J. F. Kemp, and there is certainly no one who is more highly esteemed or whose name calls forth more widespread expressions of respect and admiration.

He was born at New York, in 1859. During his preliminary years at school, his purely academic studies were supplemented by much outdoor training, received during summers spent in hunting, fishing and in other woodland crafts, which has proved of much service to him in his subsequent career. He entered Amherst College and was there drawn to the study of geology by Prof. B. K. Emerson. The contagious enthusiasm of Prof. Emerson has exercised a most important and widespread influence on North American geology, for in addition to the many valuable contributions made to the science by Prof. Emerson himself, he has inspired an extraordinary number of young men with a love for this science who, leaving his class-room, have risen to prominence in every branch of geological studies and now occupy many of the most important positions in geology and in mining in the country.

On graduating from Amherst in 1881, Mr. Kemp, attracted by the great reputation of Dr. J. S. Newberry, of the Columbia School of Mines, who was at that time almost the only teacher of economic geology in the United States, entered Columbia as a student in the course of Mining Engineering and completed his course for the degree of Engineer of Mines in 1884. While following this course he gave special attention to the subject of practical geology and, during his summers, visited several of the great mining camps in the Lake Superior

*Dean of the Faculty of Applied Science, McGill University, Montreal, Can.

region and in Colorado. Upon graduation, he secured a position with the Rand Drill Co., but later returned to Columbia, where for a time he acted as assistant to Prof. Newberry. He subsequently went to the University of Munich for graduate study, but returned to America in 1886 to become instructor in geology at Cornell University. He was promoted to the position of assistant professor at that university in 1888. In 1891, however, Prof. Newberry's health had failed, and Prof. Kemp was called to Columbia as adjunct professor of geology. In the following year he was appointed to the full professorship in that science, and has been the head of the Department of Geology at Columbia University since that time. Under his able leadership and administration, Columbia has been one of the greatest centers of geological study in the United States, attracting a large number of students, not only from all parts of the United States itself, but from many foreign countries. The original staff of one professor with an assistant at the time of Prof. Kemp's appointment, has grown with the increase of the number of students and now consists of four professors, a curator and three assistants.

Throughout his career Dr. Kemp has paid especial attention to the application of geology to mining, and especially the relation of that science to ore deposits. His book on the ore deposits of the United States and Canada is used as a text in every mining school in North America. In pursuing his varied studies, Dr. Kemp has traveled very extensively and made special investigations in all the mining regions of the United States; he has also made three visits to Mexico and many to the Dominion of Canada, and has visited most of the more important mining districts of Europe. is work on the iron ores of the Adirondack Mountains may be especially mentioned, as well as the numerous and very important contributions which he has made to our knowledge of the development of ore deposits in contact zones and elsewhere, through the action of magmatic waters. His views upon the rôle played by magmatic waters in volcanic action have received a very brilliant and striking confirmation from the recent researches at Hawaii of Dr. A. L. Day, of the Carnegie Institute, the results of which have just been announced at the last meeting of the Geological Society of America at New Haven. His papers published in various scientific journals and magazines number close upon one hundred titles. Prof. Kemp received the degree of Doctor of Science, *honoris causa*, from Amherst on the occasion of the 25th anniversary of his graduation.

Dr. Kemp is a member of the National Academy of Sciences, of the Philosophical Society of Philadelphia, and has twice been President of the New York Academy of Science. He has been Vice-President of the Geological Society of America and was one of the nine incorporators of the American Institute of Mining Engineers, of which he is now President. He is a corresponding member of the Academy of Sciences of Christiania, Norway; of the Geological Society of Stockholm, of the Canadian Mining Institute, and of the Sociedad Antonio Alzate of Mexico.

In addition to the distinction which Dr. Kemp has achieved as an investigator, he is noted as an excellent and inspiring teacher. His former students are to be found occupying important positions in every mining center in North America. In the course of an after-dinner speech some years ago, a well known mining engineer, in proposing Dr. Kemp's health, referred to this fact, remarking that although the West might be "wild and woolly," he had never seen a part of it which was "un-Kemp-t." All of these students without exception, look back to their association with him at Columbia as one of the most fortunate incidents in their lives.

Dr. Kemp's charm of personality and manner is known to all, and his confreres hope that he may long be spared to illuminate the problems of American mining geology by the wealth of his knowledge and experience.

Ralph Davenport Mershon, President of the American Institute of Electrical Engineers

By G. A. Wardlaw*

In the early eighties, George Westinghouse, with characteristic foresight, discerned the great future of the alternating current. He, having pinned his faith to it, was always alert in finding the brightest minds to help develop his ideas. Under his direction, Stanley and Shallenberger were hard at work at Pittsburgh, perfecting the alternating-current system. About 1884 he acquired the Gaulard and Gibbs patents on series transformers, and then began to manufacture alternating-current machinery on a commercial scale.

Electrical engineering was becoming both fascinating and fashionable. The scientific schools were promptly abreast of the times, the practical training of embryo electrical engineers being carried on with such apparatus as the schools were able to get at that time. The electrical tree had taken deep root in a receptive and nourishing soil and was growing apace in trunk and branches. Coincident with the beginning of the manufacture of commercial alternating-current machinery in America was the founding of the American Institute of Electrical Engineers in 1884, with Norvin Green as its first president. The telephone, the electric railway, the central lighting station, the electric industrial motor and alternating-current power transmission were all pushing forward rapidly.

At that time, too, Tesla was independently working out his own ideas, spurred on, no doubt, by the stories from Pittsburgh of the ingenuity and industry of the small group of electrical engineers in the research laboratory of the enterprising Westinghouse company. It was a lively race between Tesla and Stanley and Shallenberger, both sides working along the same lines and both eager to be the first to startle the world with a commercially efficient alternating-current induction motor. Tesla won by a narrow margin, describing his polyphase induction motor, operating with a rotating magnetic field, before a meeting of the Institute on May 16, 1888. The announcement of the development of the Shallenberger alternating-current energy meter followed almost immediately. Shortly after that, the Westinghouse company acquired the rights of the Tesla patents, thereby completing the final link in the alternating-current chain.

While the early experimental work with alternating-

*Editor of the "Electrical Record," 114 Liberty St., New York City.

current machinery was being carried on in the Westinghouse laboratories, a number of youthful aspirants to engineering fame were being trained at several of the college scientific schools. A kindly fate had decreed that their paths should converge at Pittsburgh, whither 'tis pleasing to fancy they were lured by the enterprise of Westinghouse and the work of Stanley and Shallenberger. Thither came E. W. T. Gray from Dartmouth, Charlie Young from Princeton, Billy Blunt from Lehigh, Calvert Townley from Yale, Philip Barton from Cornell, Lewis B. Stillwell from Lehigh, Charles F. Scott from Johns Hopkins and Ralph D. Mershon from Ohio State.

All these young engineers were members of the Amber Club, now famous in song and story in that part of western Pennsylvania. They lived together in a rented house, one of them acting as steward, being graciously permitted in this way to test his ability as an engineer by trying to "do for one dollar what any blunderer could do for two." The professional work of this group of fast developing engineers was carried on in the Westinghouse shops under the inspiration of the talented Stanley and Shallenberger; possessing ability, capacity, endurance, enthusiasm, and youth, there was no holding them back. They discussed their work at night, compared notes, debated and argued. Consciously or unconsciously they influenced one another to an unusual degree. No man in that club, it is reported, was without opinion and conviction on the engineering, political and economic questions of the day.

Of this rather remarkable group of young engineers (all of whom have since occupied positions of unusual trust and responsibility, and one of whom, Charlie Young, like the gentle and heroic Shallenberger, gave all that he had to give, his life, in the interest of his profession), three were graciously gifted with more than ordinary imagination. These three had the sort of imagination that loses none of its creative qualities when alloyed with that other rare quality, common sense. As sensible, shrewd, creative engineers, they had no alternative but to climb to the top of their profession and to win, within the next twenty years, the highest honor that the profession in this country has in its power to bestow—the presidency of the American Institute.

Here, then, were three youthful engineers from different scientific schools, all at work in the same shops, all living in the same club at the same time, all creating alternating-current apparatus of increasing importance in the development of alternating-current power transmission throughout the world. All were destined to sail widely diverging courses in later years and then, not to have their ways converge again but, strangely enough, to become captains, and, in one decade, to guide the American electrical ship of state, the American Institute of Electrical Engineers, through the turbulent seas and buffeting winds that always beset such craft. The three clubmates whom the Institute has thus honored in the last ten years are: Charles F. Scott, inventor of the two-phase-three-phase transformer, president in 1902-03; Lewis B. Stillwell, inventor of the Stillwell regulator, president in 1909-10; and Ralph D. Mershon, inventor of the six-phase rotary converter and the compensating voltmeter, president in 1912-13.

It was in 1891 that Mershon went to the Westinghouse company after being graduated at the Ohio State University and serving there for one year as assistant instructor of electrical engineering; at that time he was 23 years of age. Like some of the young engineers at Pittsburgh, he acquired experience in all the important departments, including patent experimental work, commercial work and selling. To him was assigned the designing of the transformers for which the Westinghouse company received the gold medal at the World's Columbian Exposition in 1893. He also designed the transformer for the Pomona plant in California, the first commercial high-tension transmission system in the world. The then high potential of 10,000 volts was used.

Several years later, he was at Telluride, Colo., investigating, for the Telluride Power Transmission and the Westinghouse companies, the phenomena that occur between conductors at high voltages. This investigation was carried out on a transmission line about two and a half miles long. Original methods were devised by Mershon for doing this work, and special apparatus was designed and built by him by means of which quantitative measurements were made up to 72,000 volts. At the completion of the quantitative work, the pressure was carried up to 133,000 volts, at that time by far the highest voltage that had ever been impressed on an outdoor line. He made a masterly report on the results obtained and submitted it to the Westinghouse company, with which it has ever been a highly treasured document.

It was while doing this work that Mershon showed the sort of stuff he is made of. Those who worked with him in that bleak country say that ailing or well—and he was ailing most of the time—he stuck to his hard task. The climate did not treat him kindly; the snow was deep and treacherous; the food was rough and, to him, indigestible; the work was protracted and arduous. Day after day he struggled, half sick, through the deep snow, loaded down with heavy coils of wire and no less heavy instruments. And night after night he doggedly analyzed his data and formulated his conclusions. This detail is mentioned, not as a matter of sentimental heroics, but to give some idea of the man's grit. Pluck is one of his most pronounced characteristics, as the following story bears witness.

A man now holding an important executive position with a large corporation was a member of the Amber Club with Mershon. In talking about club matters only a few days ago, this man said:

> Some of the happiest days of my life were spent in that rickety old club house in East Liberty. Every member had pronounced characteristics. There wasn't a commonplace man in the lot, and I always thought the most interesting personality was bound up in Mershon, of Zanesville. To test his metal we older men used to try to "put things over on him," as the saying goes. When he said he didn't feel well we craftily tried to take advantage of his physical weakness and get him to change front on certain fundamental engineering and economic questions. No matter how sick he felt he never flinched. With back to the wall, he always fought us to a standstill. Then we let him alone, and shifted our attack to some other member with less of the hickory and more of the willow in his makeup. Frankly, there were some things about Mershon that I did not particularly care for. But admire him, I had to, in spite of myself. To put it figuratively, I didn't like the color he was dyed, but, by heck! color or no color, he was all wool and a yard wide. There was no make-believe about him; I have never met a man with a more rigid sense of duty.

Mershon secured leave of absence from the Westinghouse company in 1897-98, to act as chief engineer of the Colorado Electric Power Co. during the designing and installating of their electric-power system, which generates current by steam at Cañon City and transmits power

at 25,000 volts a distance of 25 miles to Cripple Creek, where it is used for mining. From 1898 to 1900 he was engineer of the New York office of the Westinghouse Electric & Manufacturing Co., but during the latter year he resigned to enter upon private practice as a consulting electrical and mechanical engineer in New York City, with a branch office in Montreal, Canada.

Some of the more important pieces of engineering work accomplished by him since entering practice as a consulting engineer are: the reconstruction and enlargement of the waterwheel, generating, transforming and transmitting equipment of the Montreal & St. Lawrence Light & Power Co. (now a part of the Montreal Light, Heat & Power Co.), transmitting 20,000 hp. at 25,000 volts to Montreal, a distance of 17 miles; the design and supervision of the first transmission plant of the Shawinigan Water & Power Co., transmitting power at 50,000 volts a distance of 85 miles to the same city; the design and installation of the substation equipments of the Montreal Street Ry. Co., having an aggregate capacity of about 12,000 hp., for utilizing power transmitted to Montreal from various hydraulic plants; the design and supervision of the transmission plant of the Niagara, Lockport & Ontario Power Co., for transmitting power at 60,000 volts from Niagara Falls to various points in New York State.

In 1905, and for several years thereafter, he was retained on the work of the Victoria Falls Power Co., in connection with the installation of their steam stations near Johannesburg, South Africa, for supplying power to the gold mines of the Witwatersrand, and in connection with the proposed transmission of power from Victoria Falls on the Zambesi River, Rhodesia, to the Rand, for operation in connection with these steam stations. He was the only American engineer so retained.

When Scott became president of the American Institute, in 1902, he did not forget the old days in Pittsburgh and the later ones in Colorado. He knew on whom to call for pushing through one of his most important projects to a successful and practically useful conclusion; Mershon was induced to undertake the hard job of chairman of the newly formed High-Tension Transmission Committee, the most important committee from an engineering standpoint in Scott's active and progressive administration. Now Scott made no mistake. Mershon planned a series of papers and discussions on high-tension transmission that the Institute has always been proud of. He went about it in his customary way, arranging all details, even to the editing of the papers and discussions. He was after something definite and he got it. These results, embodied in about 800 pages of the Institute *Transactions* were considered so valuable that a publisher of technical books arranged to republish them in book form, giving the Institute a small royalty on sales. The demand for this book has been so large that not only has the prestige of the Institute been much enhanced, but its treasury has been materially enriched by the royalties. No member ever served the Institute more faithfully or more unselfishly than did Mershon during the seven years that he was chairman of its High-Tension Transmission Committee.

There was a little opposition to the course of this committee from some who thought the time and money spent in a futile way. But the dissenters shortly ceased comment, and one of them actually became the enthusiastic chairman of the high-tension committee of another society, where he copied Mershon's methods. But the members of the Institute at large did not need to be thus converted. They realized the nature of the work, its value, and the great accomplishments. They gave Mershon the best they had to give in return—the office of president during 1912-13.

He is a member of the American Societies of Mechanical and Civil Engineers, of the Canadian Society of Civil Engineers, the American Electrochemical Society, the Franklin Institute, the American Association for the Advancement of Science, and he is president of the Inventors' Guild.

Enough has been said here to show what sort of man the present head of the American Institute is. His most characteristic traits are perhaps his steadfastness under adverse conditions and his persistent individuality. He is versatile, but with all his versatility he is thorough—a rare combination. In him there is a touch of Ben Franklin, of whom it has been said he was an excellent printer, but he used his trade only as a means. The development of his mind and his manhood went on above it. Printing with him was not an end of life; if it had been, someone else would have built the kite that exchanged the first kiss with electricity. So with Mershon, if he had devoted his life solely to engineering, someone else would have had to labor to produce his many notable contributions to our knowledge. Better than any other man, it seems to the writer, Mershon squares with the definition which says: "An engineer is a compound of common sense and mathematics. If he has not enough mathematics, his lot in life will be hard; if he has not enough common sense, God pity him." Here is a man, now in his forty-fifth year, who is so well fortified with the fundamentals of mathematics that he has not tasted this particular form of hardship. If, according to the latter part of this definition, absence of common sense is a cause of pity, no pity need be wasted on him for, to those who really know him, he is the embodiment of native shrewdness and unusual common sense.

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Forestry in the Owens Valley on land acquired in connection with the Los Angeles Aqueduct and the new water-supply for Los Angeles has included the planting of 170,000 black locust trees up to July, 1912, and in addition the planting of 1½ tons of walnuts in nurseries. It has been found that the eastern black walnut and the California walnut, which grows in the north part of California, will both flourish in the Owens Valley. The report states:

The lumber obtained from these trees is of value for ornamental finishing and furniture. The northern California walnut has the dark walnut color, but with a reddish rather than a brown tint. The black locust also grows very rapidly in Owens Valley and makes a high-grade hardwood, suitable for fence posts, railroad ties, wagon work, and many other uses where a hard, tough wood is desired. The moist bottom lands in the valley will support the growth of these trees, and it is believed that the city should develop extensive forestry interests on these areas.

The Highway Work in Louisiana, done by the Highway Department of the Board of State Engineers during 1912, aggregated 127.4 miles, of which 100.75 miles were built by contract and 26.63 miles by convict labor. The total cost was $199,931, of which $29,945 was for the convict camps, $101,099 by the parishes (for contract work) and $68,887 by the state (for contract work). The contract work included 88.75 miles of earth roads, 8 miles of shell roads and 4 miles of petrolithic roads, the average cost per mile being $1380, $2949 and $4914, respectively. The earth roads built by convicts averaged $1124 per mile. The road work done under this department from Jan. 1, 1908, to Jan. 1, 1913, has aggregated 299.3 miles, of which 125.2 miles were built by contract and 174.1 miles by convicts. The above figures are from a statement furnished to us by C. C. Sandoz, Secretary of the Louisiana State Highway Department.

Grouting a Bank Revetment with Molten Slag

The Wheeling & Lake Erie R.R. is doing some interesting work in the revetting of embankments along the Ohio River, and in grouting the revetment with molten slag (and cement grout in some places). For particulars of this work we are indebted to W. L. Rohbock, Chief Engineer of the railway.

FIG. 1. EMBANKMENT REVETTED WITH MOLTEN SLAG

The embankment where this revetment was built extended for a length of about 3500 ft. at both Brilliant and Rush Run, which points are some five miles distant from each other. The height of the embankment at both these places is about 30 ft. The original single track was on a more or less side-hill cut, and the construction of the second track necessitated the widening out of this embankment on the side next the river. This widening was started by dumping heavy mill refuse together with clay and ordinary slag. As this filling progressed it became necessary to protect the slopes with revetment. This was done by placing heavy mill slag along the face of the slope, building it up in the form of a wall at an inclination of about 1 on 1, a trench being dug at the foot of this wall to provide a toe hold.

The pressure from the hill on the opposite side of the track seemed to have a serious effect on this embankment, particularly in wet weather. This was especially noticeable in the alignment of the old track. This pressure caused the revetment work to bulge and get very much out of line, and in two bends in the river, the revetment work was pushed out at the bottom—due to the scouring of the river. In addition to these failures it was found that the slag lumps, although of about two-man size, were not sufficient to resist the force of the river current or of the ice floes in the winter.

To obviate further difficulties it was decided to use molten slag as a coating over this revetment work and also for the purpose of reinforcing it at the bottom. The slope was increased to 1½ on 1 and at points where the river was low and the bottom of the wall was exposed, an additional trench was dug, heaping the earth on the one side to stop the hot slag from going into the river. This method proved extremely satisfactory, as the slag could be handled in quantities varying between 500 and 600 cu.yd. per day, hauling it a distance of about two miles, and handling in the neighborhood of 60 ladles (the average contents of each ladle being about 9 cu.yd.). These ladles were tipped by steam power and could be poured slowly so as to regulate the flow of the slag, thus building up the wall on a uniform slope. (Fig. 1.)

At other places along this embankment, where both slag and stone revetment was used, a cement-gun was employed to grout the voids in the revetment, using a mixture of 5 parts clean, sharp sand and 1 part cement. This material was delivered at the rate of about 15 cu.yd. per day, which covered on an average of 1050 sq.ft. of revetment. This work has so far proved satisfactory, although somewhat more expensive than using the molten slag. The purpose for which both these methods were employed was principally to provide a comparatively smooth surface for the revetment, so as to offer less resistance to the water, and to bond the comparatively small units together in order to offer a greater resistance against the pressure of the hill side. Weep holes were provided at intervals of about 20 ft., both horizontally and vertically.

FIG. 2. EMBANKMENT REVETTED WITH SLAG BLOCKS AND PARTLY GROUTED WITH MOLTEN SLAG

FIG. 3. EMBANKMENT REVETTED WITH STONE AND PARTLY GROUTED WITH CEMENT

The economy in using the hot slag protection at the rate of 600 cu.yd. per day (24 hr.), at a total cost of $100, can hardly be questioned. The work done by the cement-gun cost on an average about $6 per cu.yd. of material placed.

Air Measurement by Pitot Tubes*

SYNOPSIS—For a long while, the measurement of air currents, by means of the pitot tube, has been handicapped by great uncertainty as to the proper shape of the tube and the correct size and placing of orifices. In this article are given the shape and dimensions of a pitot tube, which has been found to be accurate over a wide range of values, together with the methods of calibrating orifices and of checking the accuracy of readings. Mention is also made of an inclined gasoline manometer, which was found to give accurate readings at low pressures, and a number of practical points are noted in connection with the use of the pitot tube in the testing of centrifugal blower fans.

The importance of mechanical draft from an engineering standpoint and its range of application in industry, have been growing steadily for the past twenty years. During this time many tests have been made to determine the laws governing the flow of air in pipes and much has been accomplished in the direction of improving the design of centrifugal blowers and of piping systems for handling air currents.

As a result of these investigations it has been established that Bernoulli's Theorem for the flow of liquids holds, with certain modifications, for the flow of air, and also it has been proved that the volume of air delivered from a fan varies directly as the velocity of the fan, that the difference in total head or pressure, between the intake and the outlet sides of the fan, varies as the square of the fan velocity, and finally that the power consumption of a fan varies directly as the cube of the fan speed.

However, in spite of the fact that these general laws have been established, there is still very great need for further experimental work, particularly in connection with a study of the causes and effects of eddy currents and of means for eliminating these power-wasting phenomena. An absolute necessity for carrying on tests of this kind is some reliable pressure-measuring device which, beside giving accurate readings, is conveniently portable and can be used for taking observations at different points in the air current. The following abstract of Mr. Treat's paper describes a form of pitot tube which he has found convenient and accurate for pressure measurements in fan-testing work, and shows also a number of the difficulties encountered in this work and his methods for overcoming them.

*Abstract of a paper by C. H. Treat, presented before the American Society of Mechanical Engineers at its annual convention in New York City, December, 1912.

Apparatus Used in Testing Fans

For the many occasions where measurements are required of the volume of air from a fan, or of the pressure and volume, better and more accurate methods are often desired, than have been commonly used. The engineer frequently needs something better than the ordinary anemometer to determine the velocity head, and a rubber tube connected to a water gage to get the static head. This is especially the case in fan-testing work where the volume varies from nothing with closed gate to a maximum with free discharge, for the measuring apparatus must be accurate through this wide range. Although the pitot tube has long been known and used there is still much doubt of its accuracy and distrust of the results obtained by it, and this is due in some cases to a lack of information as to what forms of pitot tube can *not* be used.

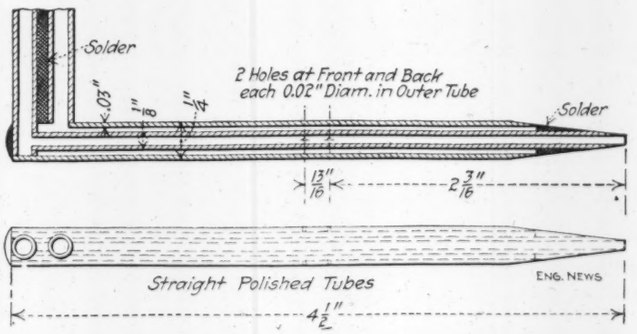

Fig. 1. Standard Pitot Tube for Air-measurement Work

In Fig. 1 is shown the standard form of pitot tube which was adopted for these tests and which has been successfully employed on similar work for a number of years. Used in connection with suitable pressure-measuring gages, this device has proved particularly well adapted for measuring both pressure and volume. It has been found to be simple, reliable, and accurate, and to be easily arranged for fan-testing.

In this tube, the static orifices, which in older pitot tube work have been the main source of errors, were clean holes 0.02 in. in diameter, in ¼-in. tubing, ½ in. thick, and they gave static readings accurate to within

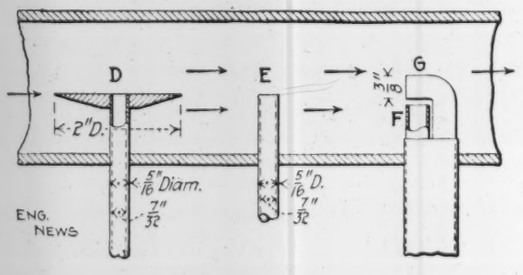

Fig. 2. Older Forms of Static Orifice

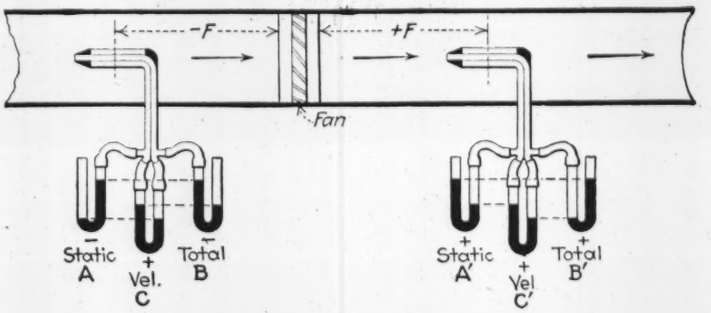

Fig. 3. Arrangement of Manometers for Reading Impact, Velocity and Static Pressures

less than 1% of the corresponding velocity head. A hole $\frac{1}{16}$ in. in diameter in this tubing gave readings considerably off, while a 2½-in. slot, $\frac{1}{16}$ in. wide, in slightly larger tubing gave static readings as much as 14% too high. A ⅝-in. slot 0.01 in. wide in the ¼-in. tube seemed to give good results, with or without an inner tube, as did the large slots if an inner tube fitting the outer to within 0.01 in. on each side. Wire cloth over the large slots appeared to give good results. However,

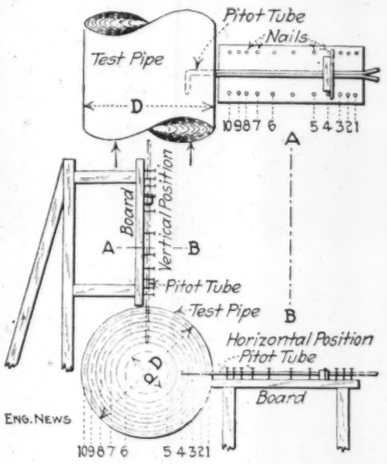

FIG. 4. ARRANGEMENT OF PITOT TUBE FOR MEASURING PRESSURES IN VARIOUS PARTS OF A PIPE

these other forms of orifice were not checked and rechecked to the same extent as the 0.02-in. holes.

Some of the older forms of static orifice are shown in Fig. 2. That marked *D* was fairly accurate, but required to be set with the plate exactly parallel to the direction of flow and this was often impossible to determine, because of eddy currents or of a whirling motion of the air current. The 0.02-in. static openings above described gave accurate results when 5° out of parallel with the direction of flow. The orifice marked *E*, a tube $\frac{5}{16}$ in. in diameter, held perpendicular to the line of flow, gave static readings too small by over 50% of the corresponding velocity reading, while that marked *F* gave readings too small by 65% of the true velocity reading.

The apparatus shown in Fig. 4 was devised for the purpose of obtaining readings of the velocity head in different parts of the pipe, so that some idea could be obtained as to the velocities in different parts of the pipe, and thereby as to the effect of friction in retarding the flow of the air.

When the air is discharged into a pipe by a fan both static and velocity heads measured from atmospheric are positive and their sum is indicated in Fig. 3 by the reading in impact manometer *B'*. When air is drawn from a pipe by a fan the static head is negative with respect to atmospheric pressure, while the velocity head is positive. The sum of the two is indicated in Fig. 3 by the reading in impact manometer *B*. The manometer arrangement used in this investigation for tests on suction is shown in Fig. 5 and that for tests on discharge is shown in Fig. 6.

The tests were made in the fan-testing room of the American Blower Company, at Detroit, Mich., using a small turbine fan for supplying the forced draft. Fig. 7 shows a view of this room and of the apparatus used in the investigation. Pipes of different diameters were used to check the accuracy of the pitot tube readings and a gasometer for measuring the volume of air displaced provided an additional check. A third check was secured by measuring the same air currents simultaneously and at the same location with two or three pitot tubes.

CALIBRATION OF PITOT TUBE ORIFICES

In deciding how to prove experimentally the correctness of the pitot tube orifices preference was given to the

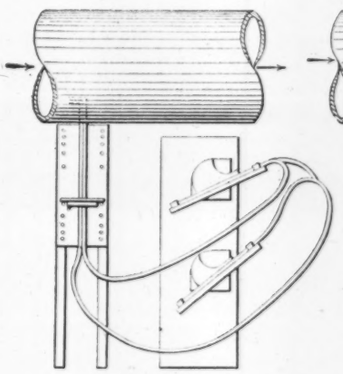

FIG. 5. CONNECTIONS OF MANOMETERS FOR MEASURING SUCTION PRESSURES

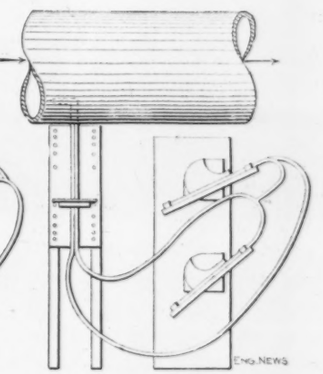

FIG. 6. CONNECTIONS OF MANOMETERS FOR MEASURING DISCHARGE PRESSURES

method which seemed most simple and accurate and which promised to be the best check on work already done. The accuracy of the impact orifice cannot be proved by means of a jet of air because the only practical means for determining the velocity at any point in the jet is by the use of the pitot tube. It would scarcely do to test the tube by means of a carrier such as a locomotive

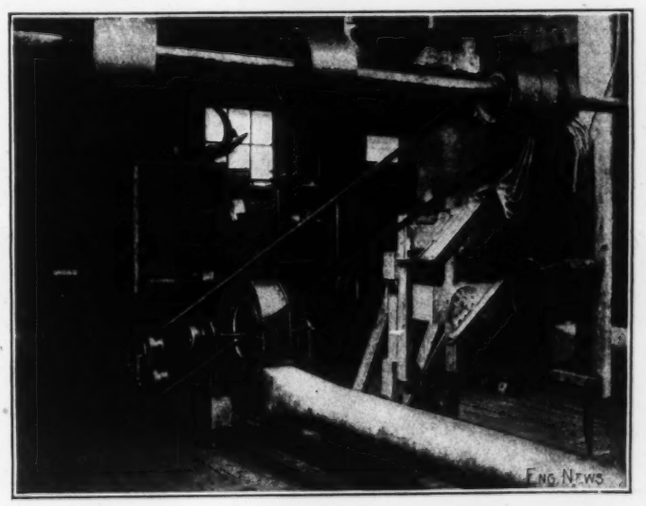

FIG. 7. VIEW OF THE FAN-TESTING ROOM AND APPARATUS

because of changing air currents. But by attaching the impact tip to the end of a slender hollow arm rotating about a shaft, uniform motion may be obtained in air having motion due only to the passage of the slender arm through it. This motion was found by tests to cause a reduction of from 2 to 5% in the readings of impact

head and to eliminate this error the device was placed on the fan shaft near the intake side and the fan allowed to discharge enough to draw the air, which was disturbed by one passage of the slender arm, away in time so that the next passage of the arm through the same part of its path was made through air undisturbed by the first passage. That is, the fan caused the air to have a motion at right angles to the direction of travel of the arm and tip instead of with it. The proper rate of flow for the best results was determined by blowing smoke into the fan intake.

The device used for calibrating the pitot tube orifices is shown in Fig. 8. The process as explained above consisted in rotating the various tips at the end of a slender arm and in noting the speed of rotation and the pressures at the axis. The arm was of brass tubing $\frac{3}{16}$ in. and $\frac{3}{8}$ in. in diameter, sweated together. Stay wires

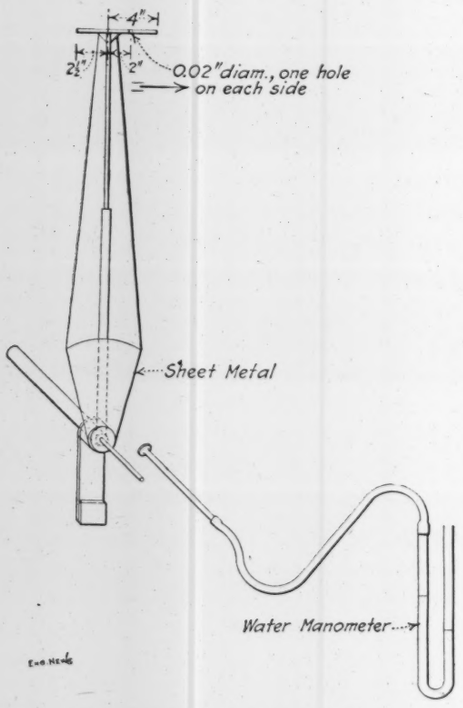

FIG. 8. APPARATUS FOR CALIBRATING PITOT-TUBE ORIFICES

were used, as shown, to give it rigidity, and the tubing was fastened to the fan shaft by a setscrew in the collar to which the tube was attached. The different tips to be tested were soldered to the outer end of this tube and to the corner braces. A small air-tight connection was afforded at the axis by a $\frac{1}{8}$-in. brass tube projecting from the radial arm and along the axis. Around this small tube there was a ring of greased candle wick, against which the cone end of a larger tube was pressed, care being taken to press only hard enough to make the joint air-tight. The arm was counter-weighted as shown.

The fan shaft was driven by an automatic engine having no other loads, so the speed was steady and uniform. Pressures were read on a vertical water manometer of large cross-sectional area (0.45 in. inside diameter) for most of the tests and for those with a small head an inclined gasoline manometer was employed. Temperature and humidity readings were taken in the room close to the calibrating apparatus. The $\frac{1}{4}$-in. tips, used in all tests except the last four, projected forward from the arm about 4 in. and backward about $2\frac{1}{2}$ in. The static orifices in the sides were located about 2 in. forward of the arm. This rotating-arm method was the one used for calibrating not only the impact orifice but the static orifice as well.

An effect which tends to vitiate the accuracy of the calibration tests unless a correction is made to offset it, is the centrifugal force acting on the air confined in the tube. This tends to suck air in at the axis and to force it outward against the impact or static pressure at the tip orifices. For an inelastic fluid the computation of this centrifugal force is fairly simple but air, being elastic, that portion nearer to the shaft presses, due to this centrifugal force, on the air further out in the tube, compressing it slightly. Therefore, the outer portion of the air in the tube is slightly more dense than the inner and this varying density makes it necessary to employ calculus to determine the difference in pressure at the two ends of the calibrating tube, due to centrifugal force.

In the calibration work the first tests were made on the impact orifices with the fan drawing away the disturbed air. Of these the ones with gate open full were affected only very slightly, if at all, by the air motion due to the rotating arm, this point being determined as above stated by testing with smoke. The air travel toward the inlet was probably never anywhere more than 300 ft. per min. With the discharge restricted there was, however, some motion of the air with the arm so the tests with full discharge deserved more consideration than those with partial discharge.

Another minor source of trouble was the tendency of the stuffing box to heat the air in the tubes slightly. This was largely overcome by the free use of soft grease on the wicking, also by reducing the pressure of the outer cone end tube, shown in Fig. 8, as much as possible consistent with maintaining the joint air-tight. Between tests fresh cool air was allowed to replace the warmed air in the tube but the results may have been affected very slightly by the air in the tube being a little warmer than that in the room. An increase of 10 degrees in the temperature in one test, without change of moisture content of the air in the arm, changed the computed centrifugal head from 4.905 in. at room temperature to 4.825 in.

Later tests were made on the impact orifice, without the fan to draw the disturbed air away. These served to show the comparison between a flat impact tip $\frac{5}{16}$ in. diameter, with a hole in the center $\frac{1}{16}$ in. in diameter, and the standard orifice, also between a $\frac{1}{4}$-in. open brass tube, with its end filed square, and the standard orifice. Some readings were taken with the back end of the tip open, using four forms of opening. One test was made to determine about what air motion the arm set up for these runs, because nearly everyone interested in pitot-tube work sooner or later wants to know what value this suction has. It evidently depends for one thing on the shape of the orifice.

In calibrating the impact orifice we have only the pressure due to impact to deal with, as the atmospheric pressure in the room is on both the tip and the pressure-

measuring instrument. The device above described and shown in Fig. 8 for calibrating orifices provides a simple means for comparing the pressure computed from the relative velocity of tip to air by the relation $V=\sqrt{2gh}$, with the pressure actually resulting from this velocity. The calibration tests show the impact or total reading to be accurate probably to within 1% in the above relation.

For computation of the centrifugal head for the static tests the pressure at the axis is below atmospheric, if the pressure at the tip is atmospheric, and the mean density in the arm is slightly less than for the impact runs, since for them the pressure at the axis is nearly atmospheric. The first tests on the static orifices were with a form of orifice, believed to be particularly accurate. The orifices were simply holes 0.02 in. in diameter, drilled through the tubing, which was about 0.03 in. thick. These holes were clean and had their outer edges square and it was found that they were small enough so that the static-head readings were independent of the inner tube in every way.

Tests were then made with a slotted static orifice. The outer tube was about 0.4 in. in diameter, its inside diameter being about 0.28 in. With no inner tube the results were poor even with this thick tube. With an inner tube central and fitting the outer to within about 0.015 in., the result was fairly good, but when the inner tube was made 0.02 in. smaller in diameter, the result was poor again. It is very interesting to know that when fine-mesh wire cloth was wrapped around the tube outside the slots, the results were good and agree with those from the small drilled holes. By comparison with the standard static orifice in air flowing in a pipe, the results were found to be considerably worse with a thin outer tube than with a thick one using the same inner tube. It was found in this way that an instrument with 2¼-in. slots, $\frac{1}{16}$ in. wide in ⅜-in. tubing $\frac{1}{32}$ in thick and with a $\frac{5}{32}$-in. inner tube gave static-pressure readings 14% of the velocity pressure too high and that holes $\frac{1}{16}$ in. in diameter in the ¼-in. regular tip $\frac{1}{32}$ in. thick also gave poor results.

Theoretical and Practical Considerations in Fan Testing

The calibration tests on different forms of impact and of static orifices developed the fact that, in using the pitot tube in air-pressure measurement, there is no difficulty in getting correct readings of impact or total head. Considerable latitude was found to be allowable in choosing the form of impact orifice without affecting the accuracy of results. The form of impact orifice most carefully checked, however, was that shown in Fig. 1. The most frequent source of error was shown in the same way to be due to incorrect readings of static pressure. It was found that the static orifice had to conform closely to certain fixed dimensions if at all accurate readings were to be obtained.

The pitot-tube arrangements shown in Fig. 5 and 6 were those used in fan testing. In Fig. 4 is shown the manometer arrangements necessary to give readings of the three heads, impact or total, velocity and static. By using the pitot tube shown in Fig. 1 where impact and static pressures are measured at practically the same point, the connections shown in Fig. 4 give accurate readings of velocity head in manometers C and C' because the pressures other than that due to velocity cancel each other. The possibility of the pressure changing between the times of reading static and impact independently is avoided and there is no subtraction to be made. The difference in static pressure between the point of reading in the pipe and atmospheric pressure in the room is read in manometer tubes A and A' and the corresponding difference in impact or total pressures is read in tubes B and B'. To read correctly either impact, velocity or static pressures the pitot-tube tip should point as nearly as possible straight into the air current.

The common pressure-measuring apparatus is satisfactory for pressures above 1 in. water gage and, for pressures from 1 in. to 2 or 3 ft. of water, manometers are reliable and convenient. Various forms of apparatus are used for measuring pressures of 1 in. or less and probably as simple and reliable a means as any is furnished by an inclined manometer containing gasoline instead of water. The tubes for this manometer should be of the same size, perfectly straight and parallel inside. When so made they can be easily used when inclined as much as 20 in. slant for 1 in. vertical reading with very accurate results. Water, however, is not a satisfactory fluid in a manometer inclined more than three to one and gasoline is recommended instead, as it is not only very active but comes accurately to the same form of surface.

The back plate is set by leveling by the bubbles in the manometer tubes and then the tubes are swung up to the angle required to give a good reading, 20, 10 or 5 to 1. In fan testing for velocity reading at different restrictions two or three slants may be used to cover the wide range in pressure and it is very convenient to cover this wide range with the one gage by the simple device of changing the angle. Good care is necessary to get the angle correct for 20 to 1 and great care for 40 to 1. At 40 to 1 slant for ½ in. velocity reading the velocity is 384 ft., for 0.49-in. reading the velocity is 380 ft., showing that with the slant gage, velocities as low as 500 or even 400 ft. per min. may be measured satisfactorily. With skill and care the hook gage gives good results if the pressures do not fluctuate. In air-measuring work the pressures usually fluctuate slightly even when care is taken to get the fan speed as constant as possible. It is desirable to be able to take the readings under these conditions, and this may be done by setting the zero-point of the measuring slide at the mean lower level, and at the instant the level comes opposite this point, reading at the upper level.

The spacing board for the pitot tube should be placed so that the tube crosses the test pipe centrally. Inclining manometers are shown for pressure measuring, but other instruments for this purpose may be used if preferred. After connecting try out the lines of tubing by noting if the liquid lowers in the manometers after pressure has been applied and make sure that the connections are not clogged. Use care to prevent liquid from being drawn from the gages into the tubing.

For a fan test the area of the test pipe should be made the same as the area of the outlet or inlet connections. Well fitted soldered pipe should be used for the test as an ordinary test pipe, unsoldered and carelessly fitted to the fan, may leak 5% or more of the air handled at ½ gate, or even at ⅝ gate, lowering the pressure correspondingly.

It is very essential to determine the relation between the volume, the pressures and the power required as the resistance changes. For this purpose it is usual to gate down the outlet for an outlet test or the inlet for the inlet test, using round orifices in thin flat plate. No air should escape except through the orifices. It is usually ample to test with gates 0, ¼, ⅜, ½, ⅝, ¾ and once the area of the orifice. Occasionally a ⅛ gate is useful. For some tests the ⅜ and ⅞ gates may be omitted. The area of the gate divided by the area of the test pipe is the ratio of opening or the equivalent orifice.

The coefficient of efflux is larger for a conical outlet than for an orifice of the same area and is probably greater for a large gate than for a small one on the same test pipe. However, a gate, say ¾, is very nearly a fixed measure of resistance. Even if it were not there would be no inaccuracy due to this cause as the final curves are ordinarily used, for the required ratio of opening is found from the required ratio of pressures. The ratio of gate area to full area is often very useful, so that it is wise to use ratio of opening for abscissa in final curves.

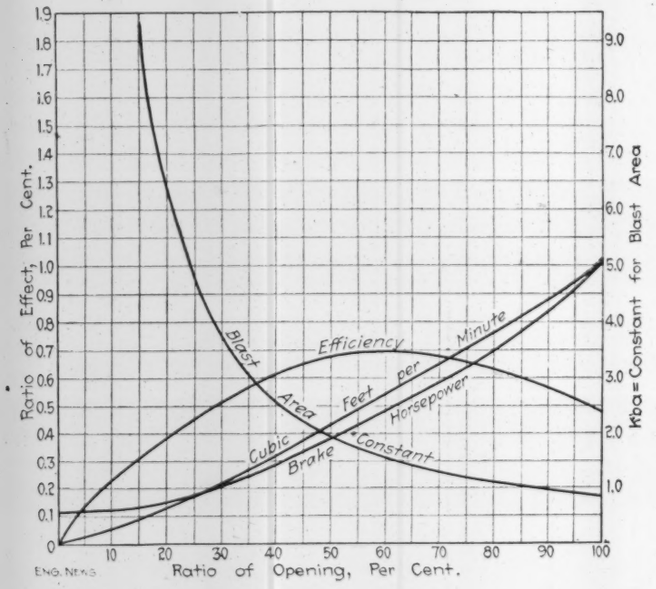

FIG. 9. CHARACTERISTIC CURVES OF A FAN TEST

In making fan tests the speed may not be constant at all times. To correct to a common speed we have relations between speed and pressure and power that have been fully verified by test. These relations (under the same conditions of resistance to air flow, density of air, and with the same fan) are as follows: (1) The volume of air discharged by the fan varies directly as the r.p.m.; (2) the pressures produced vary directly as the square of the r.p.m.; and (3) the horsepower required to drive it varies directly as the cube of the fan r.p.m.

In working up a fan test, a correction for friction in the test pipe must be made to show what the fan alone is really doing. The friction pressure or pressure to overcome this friction may be 10 or 15% of the total at wide open gate and 3 to 4% at ½ gate. For ordinary round galvanized pipe a simple and quick way to find this friction is from the formula

$$F = \frac{velocity \times L}{40 \times D}$$

Where F = friction in inches of water, L = length, and D = diameter of round pipe. It is easier to remember that the length of the pipe in which friction pressure equals velocity pressure is 40 diameters. This rule is applicable to air under ordinary conditions of temperature, pressure and humidity and values by it check closely with those given by Kent. For smooth, straight pipe, instead of 40 diameters it may be 60 or more, and for rough bended pipe the figure will be less than 40. It is interesting to note that 0.0067, the coefficient of air friction in ordinary piping is given as the coefficient of skin friction for water of rather rough surface.

It is important to have a standard weight of air at which fan performances may be compared. The density, while ordinarily a small factor, affects the results considerably, if extremes are great, as with heated air or with cold out-door air. It affects the velocity pressure, the total pressure and the horsepower. As correction to a standard involves some labor it is desirable to choose for a standard a mean weight so that the original data will be close enough without correction in many cases, or so that the conditions may be kept such as will give standard weight. Another reason for using the mean or ordinary weight is that such data as taken may be compared with previous tests, also that ordinary rough uncorrected tests may be compared with standard tests.

As fan tests are apt to be conducted indoors with warmed air the weight on the average for the year in the United States will not be far from 0.0715 lb. per cu.ft. This in fact is the average weight for a large number of tests extending over a number of years. To correct to standard air, multiply the velocity pressure, total pressure and the horsepower of the actual test by $\frac{0.0715}{wt.\ 1\ cu.ft.}$. The velocity will be the same as though found at the actual velocity pressure, but the static and total pressure change as the density, changing the air horsepower and the actual horsepower in proportion.

A fan discharging under constant conditions as to speed and resistance, will maintain a constant head and a constant velocity of discharge with changing density. In a pipe system supplied by a fan running at a constant speed, all the resistance may be classed as friction of various kinds. The impeller sets up heads, due to centrifugal force and to motion imparted to the air, which total head is resisted by internal and pipe frictions. Density of the fluid does not affect these heads, and the net head for one density will be the head for all. The velocity will be the same for all from the law of falling bodies. From this it follows that the volume discharged from a fan is the same at all densities, other conditions being the same. This is probably true of all fluids, since the coefficient of friction seems to be the same.

A thoroughly good way of making the results of a fan test available and useful is to plot characteristic curves as in Fig. 9. The original readings are first corrected to one common speed, if the speed has varied through the test, as it is likely to do from belt slip. These data at a common speed are then plotted on a preliminary curve sheet similar to the curve sheet in Fig. 10, but with the ratio of opening instead of r.p.m. plotted as abscissa. On this sheet correction can be made to standard weight

air and for pipe friction. This preliminary set of curves will usually show up a mistake in observation or in computation. From this curve sheet practically any fan problem may be solved for fans of that kind. Of course the other fans of the same line must be kept in proportion to the one tested to get the proper result.

Bernouilli's theorem states that the sum of all the pressures of a fluid at one section of a system of smooth piping equals the sum of all the pressures at any other section, pipe friction being cared for by the difference in friction pressures. If a fluid motor be introduced between the two sections where pressures are taken it will create a difference in pressure. This difference in pressure times the fluid passing through the motor times the constants for heaviness of fluid, area, etc., gives the horsepower produced by the motor, or given to it if power is being taken from the fluid. But for the pressure caused by the motor, the sums of pressure of the two sections would be equal.

It is quite usual in buying and selling fans to understand that a certain effect on discharge shall be produced, that is, a certain volume and pressure in the discharge pipe. When the work for which the fan is sold is to be done on the discharge side the inevitable friction loss in drawing air through the inlet is not to be included. It is not wanted although, as in the case of some single-inlet fans, it may be a very appreciable factor. Large inlets reduce it.

A cone on the outlet will not increase the efficiency of a fan but will decrease the power required, that is, the same volume of air will be moved through the same resistance by less power, the speed being a little slower.

The velocity is least at the surface of the pipe because of skin friction. In a square pipe the mean of the velocities and of the pressures taken at the center of a large number of equal squares into which the pipe is divided, is the average velocity and pressure in the pipe. In the case of a round pipe, divide into equal annular areas, and for each read at a point where the area inside equals the area outside. Since the velocity changes as the square root of the velocity water-gage reading, the velocities should be computed for each unit area and these values averaged. The error is small, however, if the velocity be computed from the average of the velocity pressures, being usually less than 1% from this cause.

There are usually irregularities of flow in air entering a pipe and if it is the discharge from a fan the irregularities may be considerable; in an inlet pipe there will be less, and in a cone inlet there will be considerable less irregularity of flow. The irregularity becomes less away from the pipe inlet and in 8 to 12 diameters in the case of fan discharge and in straight pipe good pitot tube readings may be taken. For accurate measurement it is recommended that both vertical and horizontal readings across the pipe be taken rather than either alone, especially if there has been a bend in the pipe or if the pipe is the discharge from a fan.

In so far as Mr. Treat's paper furnishes information as to a simple and successful pressure-measuring device for use on air currents, it is worthy of attention from all engineers in any way interested in such work. There are at present far too many indeterminate factors in the design of both fans and piping systems and the only way to attack these problems in a thorough and scientific manner is with some such testing device as is above described, which is both convenient and accurate.

The desired object, in most cases where forced draft is used, is to move a certain volume of air from one place to another at as small expense as possible. This may be done by producing an air current of large cross-section, moving at low velocity, or by producing a high velocity in an air current of small cross-section. The former method requires the use of larger fans and larger piping, each of which entails more expense and takes up more valuable space than would high-velocity apparatus, and for these reasons the latter method is in most cases preferable.

The following points in air work are too little understood and should be the subjects of extensive investigation in order that they may assume the important place to which they are entitled, in the design of forced-draft systems, (1) the effects of slant and curve of fan blades at different speeds, (2) the effect of the form of case, on fan efficiency, (3) the conditions affecting pipe friction, (4) the effects of difference of temperature between the air inside and that surrounding the pipe, and (5) the

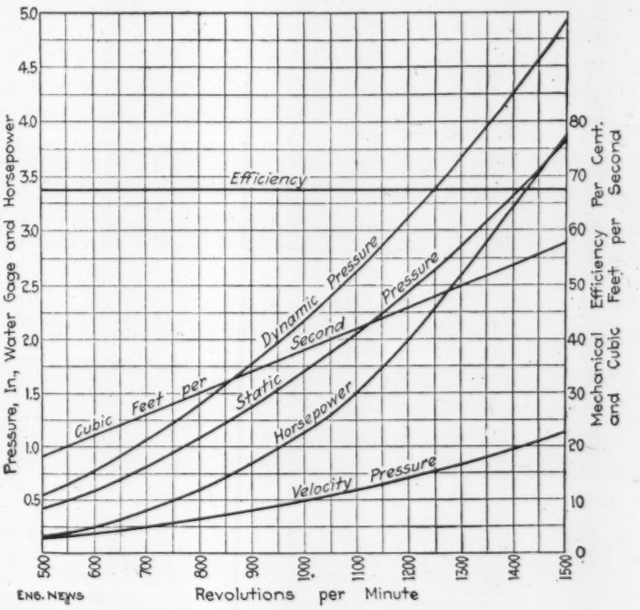

FIG. 10. PRELIMINARY CURVES OF A FAN TEST

effect of the temperature and velocity of the air current in determining the proper placing of outlets, bends or branches.

All of these points are largely affected by the velocity of the air current and it is to be hoped that the development of a good pressure-measuring device will stimulate the increased study of these problems, which their importance warrants, and which is essential to the further improvement of forced-draft apparatus.

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A Summer School of Town Planning under the auspices of the University of London was held in August, 1912, and will be held again from Aug. 2 to 16, 1913, at the Hampstead Garden Suburb, England. Lectures will be given and an opportunity will be afforded to study a town-planning project in the vicinity—a 400-acre extension scheme to the Hampstead Garden Suburb has recently been brought before the Local Government under the Town Planning Act of 1909. The summer school is designed for municipal engineers and architects. Its secretary is J. S. Rathbone, the Institute, Hampstead Garden Suburb, London, N. W., England.

A Temporary Drawbridge of the Horizontal Rolling Type

In the renewal of drawbridges on city streets it is usually necessary to provide temporary accommodation for street traffic, and an unusual way of effecting this at the Oneida St. crossing of the Milwaukee River, in Milwaukee, Wis., is described below.

In May, 1911, the Common Council authorized the sale of bonds for the construction of a bascule bridge at Oneida St., as the existing swing bridge was too narrow to accommodate the increasing traffic at this point. As this crossing of the river is within the business district, it was considered necessary to provide some accommodation for traffic during the construction of the new bridge. This was accomplished by the installation of a temporary bridge for pedestrians only, vehicles being directed to other bridges a short distance on either side.

FIG. 1. TEMPORARY ROLLING DRAWBRIDGE (FOR FOOT PASSENGERS) OVER THE MILWAUKEE RIVER, MILWAUKEE, WIS.

(Used during the construction of the Oneida St. bascule bridge)

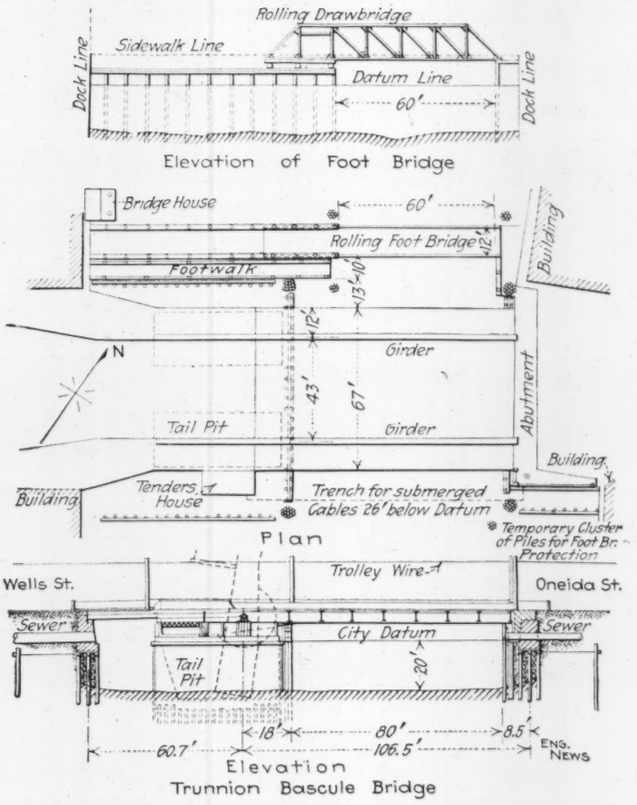

FIG. 2. PLAN AND ELEVATION, SHOWING TEMPORARY ROLLING BRIDGE AND PERMANENT BASCULE BRIDGE AT THE ONEIDA ST. CROSSING OF THE MILWAUKEE RIVER, MILWAUKEE, WIS.

The clear width of channel of the permanent bridge is 80 ft. The temporary open channel was 60 ft. wide, and this was crossed by a riveted through-truss span 91 ft. long, having one end counterbalanced and mounted on wheels running on a track laid upon a pile trestle. For information and drawings of this interesting rolling drawbridge we are indebted to J. C. Pinney, Jr., Superintendent of Bridges and Public Buildings, Milwaukee, Wis. The bridge was designed and constructed under the supervision of his predecessor, L. J. Krug.

The general design is shown in Fig. 1, in which the bridge is rolled back in position to open the channel. The arrangement of the structure and its approaches, and their relation to the permanent bridge, are shown in Fig. 2. The bridge was located north of the permanent site, and beyond the street line, being approached by a short lateral walk at each end. The pile trestle (at the west end) panel of the truss had the diagonal member omitted,

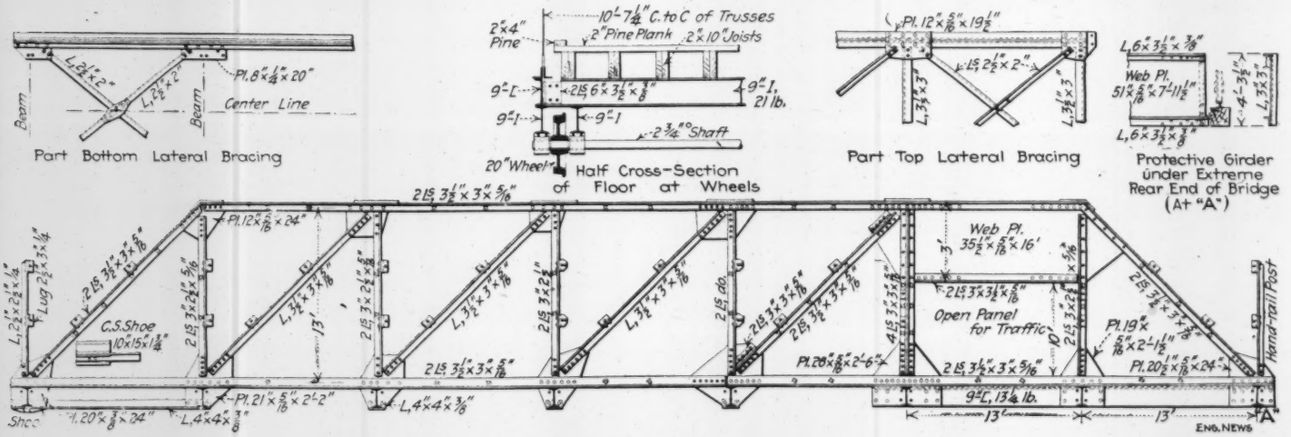

FIG. 3. DETAILS OF ROLLING TRUSS SPAN

and at the other side an 8-ft. walk level with the floor of the bridge (Fig. 4). When the bridge was opened for navigation, access to the walks was prevented by gates. When the bridge was open for passengers, they walked through one of the panels of the truss in passing from the walk to the bridge. To permit this, the rear (west end) panel of the truss has the diagonal member omitted, the stress being provided for by a 36-in. web plate in the top chord, as shown in Fig. 3. At the east end, passengers stepped on and off the bridge in the usual way, as will be seen from the plan.

The bridge was designed for an assumed live load of 100 lb. per sq.ft. The trusses of the rolling span had seven panels of 13 ft., the length over all being 92 ft. 3 in.; width, 10 ft. 7¼ in. c. to c. of trusses, and depth 13 ft. c. to c. of chords. The trusses were built entirely of angles and plates, as shown in Fig. 3, and the connections are made by gusset plates of large size. The reason for the open panel at the rear of the truss has been noted above.

The floor beams were 9-in. I-beams carrying joists 2x10-in. with a deck of 2-in. pine plank and 2x4-in. foot-

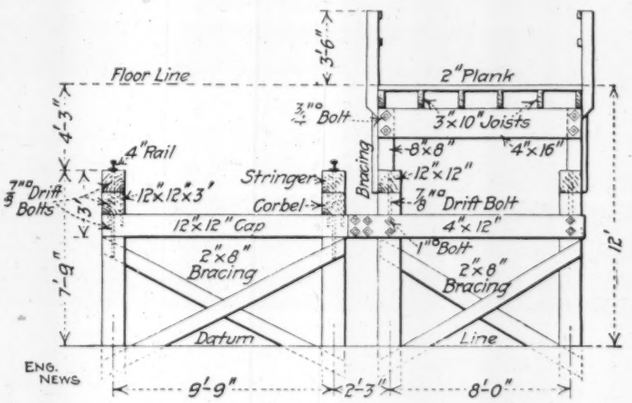

FIG. 4. SUBSTRUCTURE AND TRACK FOR ROLLING DRAWBRIDGE

guards. On each side were two hand rails of angles 2½x2 in., attached to lugs. At the forward or free end of the bridge, the two floor beams of the first panel were connected by bottom angles, serving to stiffen the bottom chords in this panel. At the heel or rolling end of the bridge are 9-in. channels, placed directly under the bottom chord angles of the two end panels. Beneath these and the floor beams were two pair of 9-in. longitudinal I-beams or sill beams, to which were attached the axle boxes of the six 20-in. cast-steel flanged wheels. This construction is shown in Fig. 3. At the extreme rear end of the bridge, beneath the floor, was a transverse protective girder acting as a stop. All field connections were bolted, to facilitate both erection and removal. The members were all marked, and when the bridge was taken down the parts were all stored, so that it will be available for use at some other time if necessary.

The trestle had four-pile bents, the inner piles 2 ft. 3 in. between centers and the outer ones 9 ft. 9 in. distant for the track side and 8 ft. for the fixed walk side. The track piles had caps 12x12 in., with corbels 3 ft. long supporting the stringers, on which were laid the rails. The sidewalk piles had stringers laid directly upon them, with 8x8-in. posts to which were bolted cross timbers supporting the floor joists. This construction is shown in Fig. 4.

The rear end of the bridge was carried by six 20-in. flanged cast-steel wheels with 3-in. cylindrical tread, running on a track 9 ft. 9 in. c. to c. of rails. As shown in Fig. 5, one of the axles was driven by gearing from a 25-hp. 500-volt series-wound direct-current motor, this being the motor which operated the old swing bridge. The motor speed was about 1200 r.p.m., which was reduced by the gearing to about 214 r.p.m. on the axle, giving a speed of travel of about 112 ft. per min. It actually required from 45 to 60 sec. to open or close the span. The weight of the truss span was about 24,000 lb., and about 30,000 lb. of counterweight was required, but considerably more than this was used.

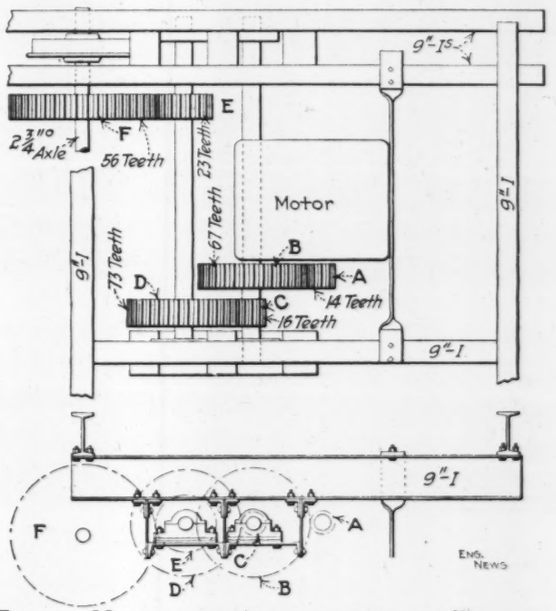

FIG. 5. MACHINERY ARRANGEMENT OF ROLLING DRAWBRIDGE

The bridge was built by the city's department forces, and the total cost of the work was as follows:

CONSTRUCTION

(A: Contract Work).	
Steel trusses and bracing	$580.00
Piling	691.20
Lumber	332.12
Machinery and structural steel	358.53
Paint	24.00
Total contract work	$1985.85
(B. Day Labor:)	
Carpenters	839.00
Ironworkers	293.22
Painters	47.40
Total day labor work	1179.72
Total cost of construction	3165.57

REMOVAL

Carpenters	58.00
Ironworkers	55.12
Laborers	65.25
Time of tug for towing to yard	10.00
Total cost of removal	188.37
Total cost of bridge erected, removed and stored in yard	$3353.84

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Rolling Stock for Spanish railways is so much in demand that the home factories can not guarantee deliveries under 12 months. In consequence it is reported that the government is intended to remove all duties on such stock for a period, in order to admit foreign cars.

The Proposed Extension of the Grand Trunk Railway System in New England

Much space has been given in the newspapers during the past two months to the proposed agreement between the New York, New Haven & Hartford R.R. and the Grand Trunk Ry., to cease competition in New England. The abandonment by the Grand Trunk Co. of construction work on the Providence extension and of its other plans for extension in New England first called general attention to this agreement and started a campaign of

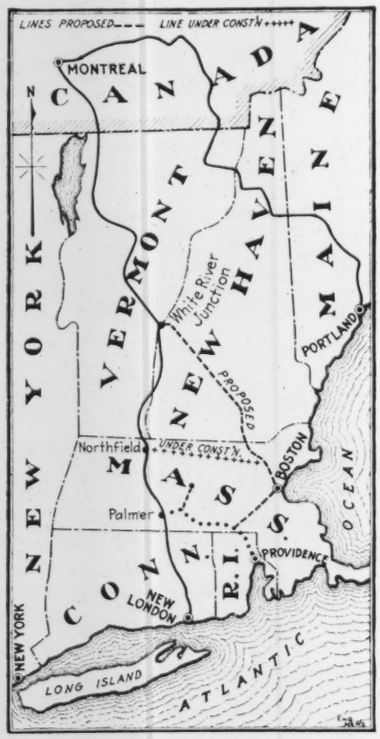


FIG. 1. MAP OF GRAND TRUNK RY. LINES TO NEW ENGLAND SEAPORTS AND PROPOSED EXTENSIONS

investigation against the New Haven Company which may have important results.

It is of interest, therefore, at this time to see what the work was which the Grand Trunk Co. had under way and projected. The accompanying map, Fig. 1, shows these extensions.

From Montreal the company has for many years had its own lines to Portland, Me., and to New London, Conn.; the latter by the Central Vermont R.R., which is controlled by the Grand Trunk Ry. From Montreal to Boston a through route is obtained by connection with the Boston & Maine R.R. at White River Junction.

The proposed extensions included the following lines: 1, from White River Junction to Boston, about 130 miles, practically paralleling the present Boston & Maine R.R. route; 2, from Palmer, Mass., to Providence, R.I., which had been placed under construction (with a branch from Dudley to Worcester); 3, from Boston to a connection with the Providence extension. All this new work was in the hands of a separate organization, the Southern New England Ry. Co., the president of which is E. H. Fitzhugh, (who is president also of the Central Vermont R.R.). For information we are indebted to Mr. Fitzhugh and to H. C. Estep, engineer of construction.

The surveys had been made for the line from White River Junction to Boston (through Nashua, N. H.), and the Massachusetts portion had been authorized by the state legislature. Should the New Hampshire legislature fail to authorize the northern portion, however, it was planned to relocate the line entirely within the state of Massachusetts, connecting with the Central Vermont R.R. at Northfield, near the Vermont boundary. This is indicated by the line of crosses on Fig. 1 Profiles of the existing lines from Portland to Montreal and Boston to Montreal were given in our issue of Dec. 21, 1911.

The Palmer & Providence line is the only one upon which extensive construction work has been done. A map and profile of the line are shown in Figs. 2 and 3. The total length is about 75 miles, exclusive of a 10-mile freight line to the water front at Providence. The length in Massachusetts is about 58 miles, with 7½ miles of sidings. In Rhode Island, however, the length of main line is 27 miles, while the sidings aggregate 38 miles. The line was planned to serve many mills and factories.

From Palmer, Mass., where the Central Vermont R.R. crosses the Boston & Albany R.R., the new line parallels the latter road up the west side of the Quabaug River, crossing this valley near West Brimfield and then looping down on the east side. Near Fiskdale it strikes the valley of the Quinnebaug River and follows this nearly to the state line, where the river runs south while the railway turns eastward through Dudley and Webster and makes a wide loop around the north and east sides of Lake Chaubunagungamaug. Thence it continues east to Blackstone and Woonsocket, where it turns southeast along the Blackstone river.

From Blackstone, the line follows the east side of the river to Albion, and then the west side. It parallels the N. Y., N. H. & H. R.R. The main passenger line tra-

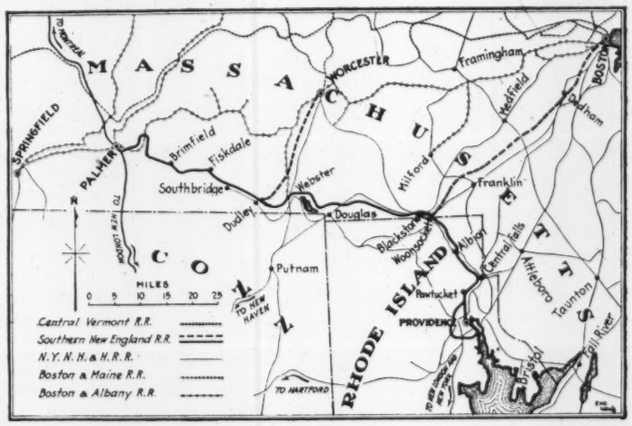


FIG. 2. MAP OF THE PALMER, PROVIDENCE & BOSTON EXTENSION OF THE GRAND TRUNK RY.

verses the city of Providence, and connects with the N. Y., N. H. & H. R.R. at a short distance from the Union Station. A freight line ten miles long swings around the city to a terminal on Narragansett Bay at Fields Point, where the company has a long lease of lands and wharves, with 900 ft. of water front. It will be seen from the map that the new line practically parallels different

lines of the N. Y., N. H. & H. R.R., and this applies also to the branches to Boston and Worcester.

The terminal elevations are 320 ft. at Palmer and 25 ft. at Providence (Union Station). There are three main summits. The first is at West Mountain (9½ miles from Palmer, near Brimfield), where the elevation is 705 ft. above sea level. The other two are in the neighborhood of Webster and the lake; at 31½ miles from Palmer is a summit of 545 ft., while at 41 miles (Mt. Daniel) is the maximum summit of 740 ft. elevation. The maximum grades are 1%, equated 0.04% per degree of curvature, with a maximum curvature of 6°. Transition curves are used, and the superelevation is calculated for a speed of 40 m.p.h. The line was to be of first-class construction, and was laid out to avoid all grade crossings, of both railways and highways.

The longest steel structure was to be a viaduct 1252 ft. long, carrying the railway over the Quabaug River (at a height of 115 ft.), the state highway and the Boston & Albany R.R. At North Webster (36 miles) is a structure 1052 ft. long which crosses the French River at a height of 55 ft.

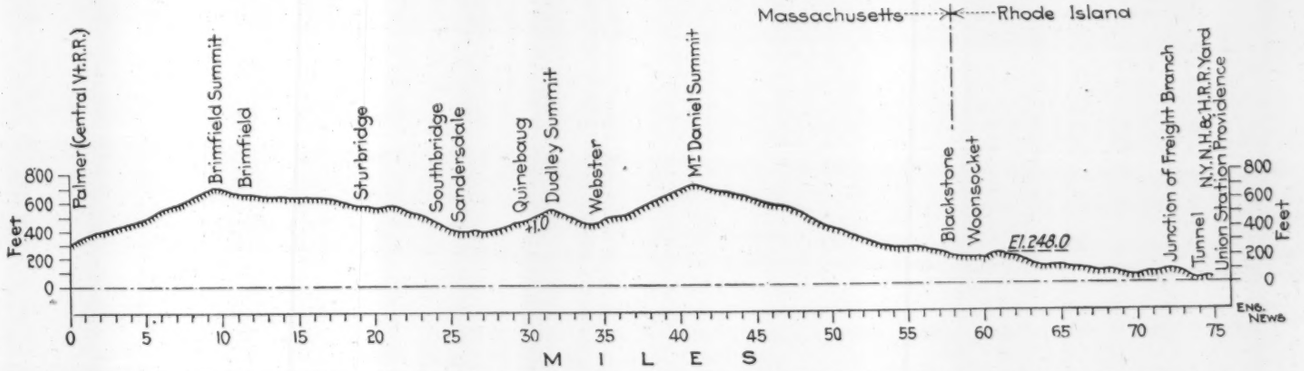


FIG. 3. PROFILE OF THE GRAND TRUNK RY. EXTENSION FROM PALMER, MASS., TO PROVIDENCE, R. I.

There was to be only one tunnel on the line, in Providence, 2400 ft. long, carrying the passenger line under the State House hill and terminating at Jewett St., near the Union Station. The freight line around Providence is for a large part of the distance depressed below the street level.

Charters had been secured for a 36-mile extention of this line from Blackstone to Boston (at South Boston), and for a 27-mile branch from Dudley to Worcester. The Grand Trunk Co. also proposed to operate steamers between Providence and New York and had placed orders for two steamers for this service, to be named the "Narragansett" and the "Manhattan", each having a capacity of 500 passengers and 500 tons of freight.

It should be said that these extensions of the Grand Trunk system were fought by the New York, New Haven & Hartford Co. by every influence at its command and there was some surveying for retaliatory lines by the New Haven as well as much bluffing.

The agreement, or rather offer, by the New Haven Co., which it is claimed led to the suspension of work on these extensions was a general proposal for trackage rights with facilities for through routing and through billing, which it was claimed would give the Grand Trunk, if the agreement were carried out, as good facilities for business in Boston and Providence as it could obtain with its own lines.

A Unit to Supplant "Horse Power"

The unit of power input, the myriawatt, recommended before the recent convention of the American Institute of Electrical Engineers (see ENGINEERING NEWS, July 4, 1912), by Mr. H. G. Stott, as desirable for expressing the power output of boilers, or the rate of steam-energy input of engines in service, has been recommended to the American Institute of Electrical Engineers and the American Society of Mechanical Engineers jointly by the Standards Committee of the former and a special committee of the latter. It is proposed as a new unit to be used in dealing with the performance of steam boilers, steam engines, gas engines, steam and water turbines, etc., and as the unit of thermal or mechanical power. It is also recommended that these two societies discontinue the use of the term "boiler horsepower." According to this practice, for instance, the rating of the steam turbine generating unit would be according to its input in myriawatts and output in kilowatts. The myriawatt is about 2% larger than the accepted definition of boiler horsepower, and is equivalent to 10 kw.

Resuscitation Apparatus—Since the importation of the first resuscitation machines ("pulmotors") by the U. S. Bureau of Mines, as noted in "Engineering News," Apr. 6, 1911, some 250 have been purchased for gas- and electric-supply companies and are in use in some 100 cities where they have been made free to the public for emergency service. According to a bulletin of H. M. Byllesby & Co., of Chicago, 11 machines were purchased in 1912, and every gas property under the management of that concern was equipped with the device. In something less than a year in which these machines had been used, 24 lives had been saved; these were mostly cases of gas poisoning, but two persons were revived from the effects of morphine, two after serious surgical operations, and one after electric shock. In one case first breath was induced in an infant.

⁂

Sieves and Sieve Cloth will be tested by the U. S. Bureau of Standards, Washington, D. C., according to information appearing in Circular No. 39 of the Bureau. The fees for this work are graded as follows:

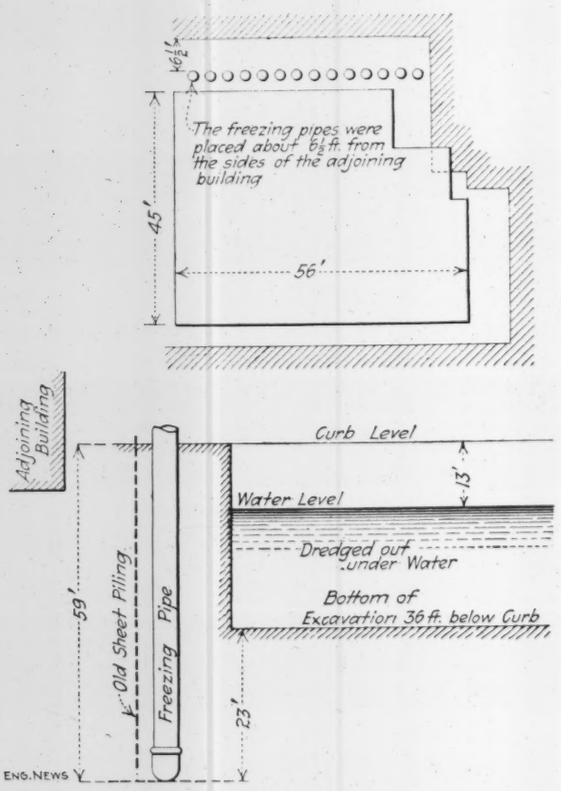
(a) Test and certification of any sieve conforming to the specifications of the Bureau of Standards	$2.00
(b) Test and report of any sieve which is rejected for mesh outside the tolerances	1.00
(c) Test and report of any sieve which passes specifications as to mesh, but is rejected for average diameter of wires	2.00
(d) Test and report of any sieve not conforming to other parts of the specifications or purchased on any other specifications	2.00
(e) Test and report of the mesh of warp wires of a piece of sieve cloth, per lin.ft.	0.60
(f) Test and report of the mesh of shoot wires of a piece of sieve cloth, per lin.ft.	0.60
(g) Determination of the average diameter of a number of wires in each direction in a piece of sieve cloth	1.00

(h) A discount of 10% on the fees above under (a) to (d), inclusive, will be allowed when sieves are submitted in lots of five or more at a time.

A Building Foundation Constructed by the Freezing Process

What is claimed to be the first use of the freezing process in constructing a building foundation is described by Maurice Deutsch in the following. Mr. Deutsch gathered the information during a recent visit to Europe, where he took occasion to study the latest methods of application of the freezing process for various purposes, particularly for shaftsinking. The work on the building foundation described below was done several years ago, but has not previously been reported in print.

In designing the substructure of a department store for R. Herzog, in Berlin, it was necessary to provide for a deep cellar where machinery was to be located. The lot is shown in the accompanying sketch: it is approxi-



PLAN AND VERTICAL SECTION OF A BERLIN BUILDING FOUNDATION CONSTRUCTED UNDER THE FREEZING PROCESS

mately 56x45 ft. The building is four stories in height, but provision was made in construction for increasing this height later. The subsoil is a bad quicksand extending to a considerable depth. Groundwater level is about 13 ft. below curb at the site, and the foundations of the adjoining buildings are about 10 ft. below curb. The cellar excavation had to be carried about 36 ft. below curb, or more than 20 ft. below water and 25 ft. below the foundations of adjoining buildings.

Work was begun by excavation inside of a sheet-pile inclosure. When this got below water-level, material from under adjoining buildings started to boil up into the excavation, and several of these buildings settled and cracked. Work was abandoned; then a concern which specializes in the application of the freezing process was called upon to construct the foundation. This concern undertook to complete the work within a stipulated time for a fixed price.

Freezing pipes 5 in. in diameter and about $\frac{5}{16}$ in. in wall thickness were sunk vertically around the site about 3 ft. on centers, on a line about 6½ ft. from the adjoining buildings. The pipes could not be located exactly on a straight line, as the sheet-piling driven by the previous contractor was not always either vertical or in a straight line. The pipes were sunk to 59 ft. below curb level, or about 23 ft. below the bottom of the proposed excavation. The pipes were closed at the bottom and inside of each was set a 1-in. brine pipe open at the bottom. The brine pipes were connected to a supply header at the top, and the 5-in. pipes were connected to a drain header. The system was supplied from a brine pump and a refrigerating plant. The brine passed down through the 1-in. pipes, up through the inclosing 5-in. pipe and back into the drain header, which returned it to the brine tank. The liquid was pumped through the 1-in. pipes at a velocity of about 11½ ft. per min. Valves fitted in the supply main and in the collecting main, and valves in the connections of the individual pipes to these mains, permitted making any necessary tests for tightness of the individual pipes.

About four weeks after the brine was started flowing the ground was frozen a sufficient distance for the contractor to begin excavation. Work proceeded by dredging inside of the lot to a depth of 36 ft. below curb. At no time did any inflow of material under the frozen wall take place. When the excavation was completed to the desired depth the floor was covered with a thick bed of concrete, placed under water. Then the site was pumped out and the foundation completed.

The work was done at a much lower cost than it could have been done for by the pneumatic-caisson process.

The Profitable Limit of a Five-Cent Street-Railway Fare*

BY HENRY G. BRADLEE†

In the 1911 report of our Committee on Rates and Fares, we indicated that it is possible to figure accurately the distance which overhead, trolley, surface, street railway cars may be operated with profit for a 5c. fare, provided four factors with reference to a company's business are shown, and we included in our report certain curves by which such calculations can be readily made.

The four items which we mentioned are as follows: (1) The total cost per car mile of operating expenses, taxes, depreciation and obsolescence. (2) The average number of 5c. fare passengers carried per one-half round trip. (3) The investment made in the company's property for each $1 of gross business. (4) The percentage return on the company's investment which must be earned to attract capital freely to the business

Since our last year's report was completed, I have endeavored to secure information from street-railway systems covering the above items. In securing this information, I have modified the items somewhat by transferring taxes, depreciation and obsolescence from the first item to the fourth. The first item, therefore, covers the total cost per car mile of operating expenses exclusive of taxes, depreciation and obsolescence. The fourth item covers the percentage return on the company's investment which must be earned to provide for taxes, depreciation and obsolescence and to attract capital freely to the business.

In presenting the information which I have collected, it perhaps, will be somewhat clearer if I consider each one of these four items separately.

*From a letter written to F. R. Ford for incorporation in the report for 1912 of the Committee on Rates and Fares of the American Electric Railway Association.

†Stone & Webster, 147 Milk St., Boston, Mass.

(1) THE TOTAL COST PER CAR MILE OF OPERATING EXPENSES

Operating expenses per car mile for those companies from which the other data could also be secured are as the accompanying table.

These figures indicate that operating expenses per car mile are not materially affected by the mere size of the road. In general, the small companies may be said to have slightly lower operating expenses per car mile than the large companies, but some of the large companies operate on a very low basis and some of the small operate on a high basis. If these companies were retabulated with reference to their geographical location, it would appear that the companies in the southeastern section of the country in general operate at a lower cost per car mile than those in the northern section or those in the extreme western section.

(2) THE AVERAGE NUMBER OF FIVE-CENT-FARE PASSENGERS PER HALF ROUND TRIP

From the figures in the accompanying table (Col. 4), it appears that the larger companies carry a greater number of passengers per half round trip than the smaller companies. The reason for this is evident. In the larger cities it is possible, to a certain extent, to vary the number of cars operated on each line from hour to hour so that the number of cars operating at any one time is approximately proportioned to the amount of traffic. In smaller cities this is usually impractical because a line which can handle its rush-hour business on a 10- or 15-minute headway cannot ordinarily reduce this headway during hours of light travel without strong objections from the traveling public.

If we consider the larger cities only, it appears that 25 five-cent-fare passengers per half trip is about as high as any road can hope to average. That we are not likely to exceed this number of passengers with the present type of car is quite evident when we consider that this figure is the average number of paying passengers per half trip covering the entire day's operation, including hours of light travel, as well as those of heavy travel, and that it does not include transfer passengers who must also be accommodated on the cars. Assuming that 25 five-cent-fare passengers is the maximum which we can hope to carry on an average per half trip, it is evident that our maximum receipts per half trip will be $1.25, and that this is the limiting factor in determining the distance which the car may be profitably operated.

(3) INVESTMENT IN PROPERTY FOR $1 OF GROSS BUSINESS

The word "investment" is intended here to cover all costs incident to the production or replacement of a property and its business.

The figures obtained showing the ratio between investment and gross earnings are as in Column 2 of the accompanying table.

These figures must, necessarily, be considered approximate because they are in all cases obtained from appraisals made after the completion of the property and at a time when the actual cost of construction was not available. All the figures are, however, based on appraisals made by competent engineers of long experience, and I think may be accepted as approximately correct. The appraisals of companies (1), (2) and (8) were made at a time when these properties were not properly equipped to handle their full gross business and give adequate and first-class service. The valuations in these cases are, therefore, low, and had the physical properties been adequate for the business handled, I think that investment per dollar of gross business would have undoubtedly been as high as $4 in each case

Taking the average of all of the companies given in the above table, I find an average investment of $3.92 per $1 of gross earnings.

It would appear from the figures that the average investment per dollar of gross business is practically the same in smaller companies as in the larger. It is, of course, true that the average investment per mile is much greater in large cities than in small. It is also true that the gross earnings per mile of track are much greater in large cities than in small, and these two factors, apparently, offset each other when comparisons are made between the total investment and the total gross earnings.

OPERATING DATA OF 20 STREET RAILWAYS

Company.	Dollars invested per dollar of gross.	Cents Operating expenses per car mile.	Passengers per ½ round trip 5-ct. fare.	Max. length half trip for profitable operation miles.
Annual gross receipts over $1,000,000				
1	3.15	14.96	22.40	4.54
2	3.25	18.33	22.80	3.69
3	4.40	18.50	25.40	3.09
4	4.00	19.60	24.40	3.11
5	3.30	16.30	17.00	3.06
6	3.90	19.00	15.60	2.10
7	5.55	19.90	22.20	1.71
8	3.03	14.22	17.50	3.82
9	4.97	15.00	27.00	3.40
Annual gross receipts over $750,000 and less than $1,000,000				
10	3.00	18.40	13.20	2.24
Annual gross receipts over $500,000 and less than $750,000				
11	3.90	18.30	14.40	2.02
12	3.00	12.60	13.00	3.22
Annual gross receipts over $250,000 and less than $500,000				
13	3.80	18.60	15.30	2.16
14	4.40	12.00	13.40	2.51
15	4.20	13.70	8.70	1.51
16	4.40	13.70	7.40	1.21
Annual gross receipts less than $250,000				
17	3.70	17.70	19.00	2.88
18	4.50	15.20	17.00	2.44
19	3.70	14.80	12.60	2.28
20	4.20	12.70	6.60	1.23

(4) PERCENTAGE RETURN ON INVESTMENT NECESSARY TO PROVIDE FOR TAXES, DEPRECIATION, OBSOLESCENCE AND TO ATTRACT CAPITAL FREELY TO THE BUSINESS

It is hardly practical to obtain definite data for this fourth item, but I think it may be possible to arrive at figures which we will all agree are reasonable.

In the matter of depreciation and obsolescence, opinions of engineers and operators differ as to details, but they agree fairly well in that at least 3% of the investment, over and above ordinary maintenance charges, should be set aside to provide for replacement of property due to depreciation, obsolescence and other causes.

I think that 1½% of the value of the physical property may be said to fairly represent the average amount paid in taxes.

The return on the company's investment, which must be earned to attract capital freely to the business is not so easy to determine. In the older communities, where conditions are more stable, an investment would, no doubt, be freely made for a lower return than would be expected in the newer and more rapidly growing sections. Considering average conditions throughout the country, however, it seems to me that a street-railway company should be able to earn 8% on its investment, if it is to secure freely the capital necessary to develop its business. It might be well to point out in this connection that the securing of new capital is, in this country, an exceedingly important part of the business of a street-railway company. The cities throughout the United States are growing at an exceedingly rapid rate and new capital must be continuously obtained if a community is to be properly served. In a group of companies scattered all over the country, with which I am familiar, the investment required has doubled on the average once in about seven years.

We have then a total of at least 12½% on the company's investment which should be earned to provide for taxes, depreciation and obsolescence and to attract capital freely to the business.

(5) THE MAXIMUM LENGTH OF HALF TRIP IN MILES FOR PROFITABLE OPERATION

Taking the above figures and applying them as indicated in our 1911 report, we arrive at the accompanying figures as the maximum length of half trip in miles for profitable operation:

These figures indicate that passengers may be profitably carried a longer distance in the large cities for a 5c. fare than in the small cities. This is due to the fact that in the large cities the number of passengers carried per half trip and, consequently, the receipts per half trip are greater than in the small cities. It would appear, however, that even in the large cities a distance of 3½ to 4 miles in the maximum length of half trip for profitable operation, if we assume, as above, that 12½% should be earned to provide for taxes, depreciation and obsolescence and a reasonable return on the capital invested.

As a matter of fact, there are, of course, a considerable number of the larger cities in which the length of half trip would average over 3½-4 miles, and it is evident that in the cities where this condition exists, the companies are either operating under exceptionally favorable conditions as to investment or low operating expenses per car mile, or, they are not earning 8% on their investment after setting aside 3% for depreciation and obsolescence. The truth is that there are very few street railways in the country which are today earning 8% on their investment and setting aside 3% for depreciation and obsolescence, after paying all operating expenses and taxes.

Rapid Construction*

An instance of rapid power-plant construction is shown in the extension of the existing Jordan steam station of the Utah Light & Ry. Co., at Salt Lake City,

The original station† was designed and built by the same engineers in 1910 and consisted of an 8500-kw. single-unit steam-turbine station designed to act as an adjunct to various hydro-electric plants operating in the vicinity and also to form the nucleus for such steam generating equipment as might be later required to serve Salt Lake City. The operating conditions covering the original plant were as follows: (1) Wyoming coal was to be used, carrying about 11,700 B.t.u. per lb.; (2) ample condensing water was available, but unsuitable for boiler feed; (3) feed water was to be purchased at comparatively low cost; (4) operation was not to be continuous at first.

The new work, which consists of an extension to the old station, comprises in general a brick and steel building approximately 100x60 ft. The building walls rest on a pile-and-concrete base composed of 36-ft. piles overlaid with about 3 ft. of concrete. Condenser intake and overflow flumes are formed in the foundations. The boiler room consists of a steel-frame structure, supporting overhead coal bunker, with brick walls, concrete-slab floors and roof. The turbine room is similarly constructed, the only steel, however, being in the crane rails, floor-beams and roof trusses.

The new boiler equipment consists of six water-tube (Stirling) boilers, with mechanical stokers; natural draft is furnished by a radial-brick stack 11½ ft. in diameter, 225 ft. high. Piping is designed with welded flanges for high-pressure work and cast-steel fittings and valve bodies.

It was not necessary to store coal in large quantities, so the coal- and ash-handling equipment is comparatively simple. It consists of a track hopper, into which coal is dumped from railroad cars and carried by an inclined bucket conveyor up to the top of the boiler house, where it discharges on a horizontal belt by which it is distributed through the length of the bunker over the boilers. Ashes are dumped from ash pits into side-dump cars, which run on an industrial railroad in the boiler-room basement, are lifted to ground level by an elevator and run out by hand to dump on adjacent land which is being filled. Good natural illumination of the boiler room is provided by skylights placed just beneath the coal bunkers.

The new generator equipment consists of one Westinghouse-Parsons turbine, 8500-kw., 3600-r.p.m., three-phase, 4400-volt unit. A Leblanc condenser‡ is placed directly beneath it in the turbine foundation, the condenser having turbine-driven air and circulating pumps. The main generator is provided with the usual air ducts for ventilation and is excited by a turbine-driven set of 100-kw. capacity. The switching apparatus is contained in concrete cells and the ring type of bus is used to secure the desired flexibility in switching operations.

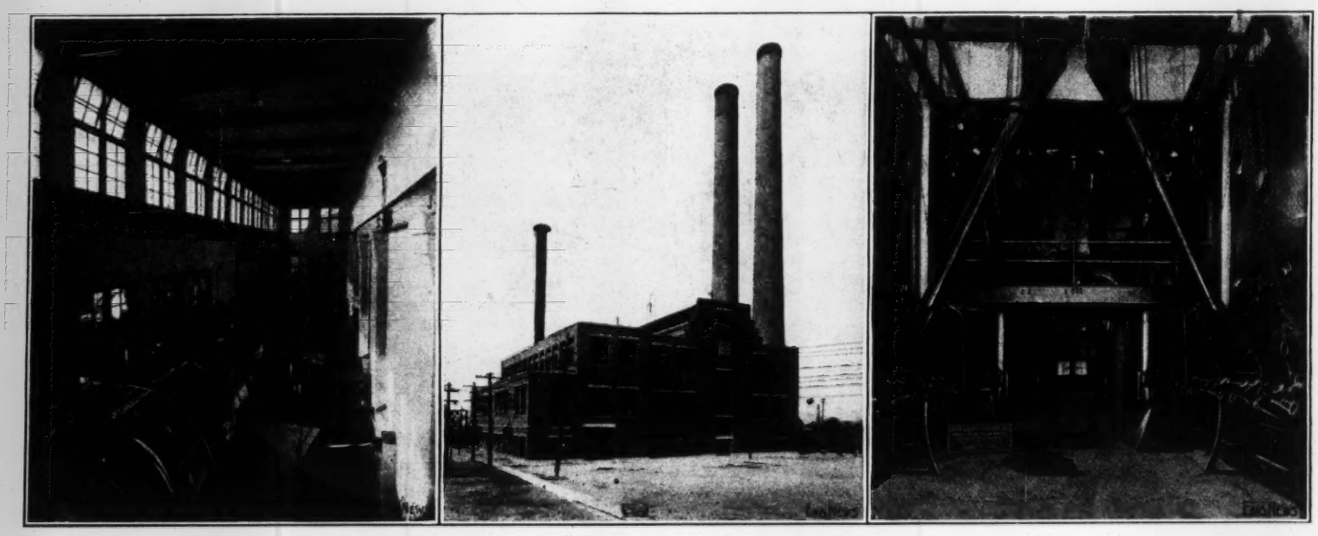


FIG. 1. THE JORDAN STATION OF THE UTAH LIGHT & RY. CO., SALT LAKE CITY
(Extensions for Unit 2 in foreground.)

The record of construction is graphically shown by Fig. 2, and may be thus summarized:

March 27, 1912. Authorization received to design and build an extension to the original station, increasing its capacity 100%.

Apr. 1. Five days after authorization sufficient progress had been made so that the main generator unit, the boilers, condenser, stack, heater, stokers and piles had been purchased. Inquiries for steel had been sent out and contracts were let for steel on Apr. 3.

Apr. 6. Ten days after authorization the field organization arrived in Salt Lake City and excavation was at once started. Construction office, storeroom and cement sheds were built.

Apr. 19. Twenty-three days after authorization, the first piles were received and driving was begun, the stack foundations being finished on May 20.

May 9. Forty-three days after authorization, stack brick work was started together with concrete building-foundation work. On May 19, brick building walls were begun; on May 21, boiler-foundation piers were started and on May 28 steel framing for boiler-room floor was begun.

May 27. Sixty-one days after authorization, the boilers began to arrive and sheet piling for condensing water intake and overflow flumes was started.

July 8. One hundred and three days after authorization, piping erection was commenced.

July 10. One hundred and five days after authorization, steam end of main generating unit arrived and was unloaded

*From information supplied by Westinghouse, Church, Kerr & Co., 10 Bridge St., New York City.

†Described in Eng. News, July 20, 1911.

‡Described in "Engineering News," Aug. 19, 1909.

and put in position, condenser having been unloaded and placed about a week previously.

Aug. 1. One hundred and twenty-six days after authorization all structural work was finished including brick walls, floors and roof, three boilers had been erected and tested and five out of the six stokers erected.

Aug. 6. One hundred and thirty-one days after authorization, main generator arrived and was placed on foundations; auxiliary work, wiring up and miscellaneous work went rapidly forward until Aug. 26—152 days after authorization, the station was put under commercial load.

It is believed by the constructing engineers that this record has never been exceeded when the size of the station and its location is considered.

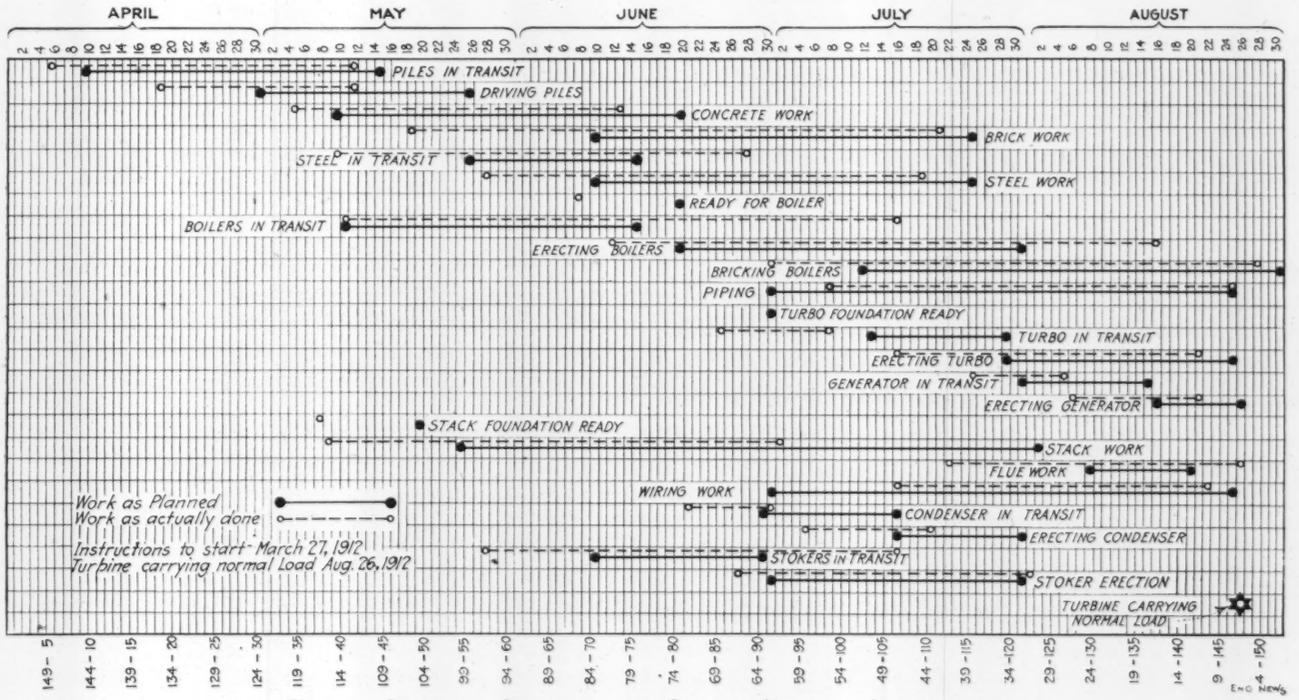


FIG. 2. PROGRESS DIAGRAM FOR JORDAN STATION EXTENSION

The work was designed and constructed by Westinghouse, Church, Kerr & Co., under the direction of O. A. Honnold, Electrical Engineer of the Utah Light & Railway Co.

Extinguishing Fires with Sawdust*

BY EDWIN A. BARRIER†

In the latter part of July last, word was received from the Stanley Works, New Britain, Conn., through the Manufacturers' Mutual Fire Insurance Co's. office, that experiments had been conducted at that plant on the extinguishing of fires in burning lacquer by means of sawdust, and that the results had been very satisfactory. A report was also sent covering in detail two tests which had been made.

The low cost of the material used, the simplicity, which makes its use more nearly resemble the fire pail than anything that has been previously suggested, the entire absence of any automatic device likely to fail to work at time of fire, and the fact that no special training would be necessary to enable the operatives to efficiently use the sawdust seemed to justify careful consideration of the subject before it was dismissed. At the request of the Department, the Stanley Works very kindly consented to repeat the tests in the presence of a representative of the Department. The writer was assigned to this work.

Although these tests at New Britain were entirely satisfactory, the proposition of putting out fires with a combustible material, such as sawdust, seemed to be so unusual that it was felt desirable to conduct a more extended series of tests. Especially was it desired to learn the effect of varying the size of the tank, the depth of the lacquer and the kind.

Three tanks were accordingly obtained, built of sheet steel reinforced with angle irons. The largest was made 60 in. long, 30 in. wide and 16 in. deep; the middle tank 48 in. long, 14 in. wide and 16 in. deep, and the smallest 30 in. long, 12 in. wide and 16 in. deep. The joints were made tight with silicate of soda cement. Both soft- and hard-wood sawdust was obtained from a local sawmill. The soft-wood sawdust was probably a mixture of pine and spruce, and the hard-wood apparently mostly oak. One barrel of sawdust was thoroughly dried to note the effect, if any, of moisture. It was thought possible if sodium carbonate were mixed with the sawdust that the formation of carbon dioxide by the decomposition of the bicarbonate by heat might be of help in extinguishing the fire. A bushel of soft-wood sawdust was accordingly mixed with 10 lb. of commercial bicarbonate of soda and used in the cases mentioned below. An ample supply of sand was also provided.

Commercial lacquer, as used in their respective plants, was obtained from the General Electric Co. at Lynn and the Stanley Works at New Britain. From their general appearance and odor, it is certain that they both were amyl-acetate-pyroxylin lacquers with the usual thinners, such as wood alcohol, benzine, etc.

The tests were conducted at Woburn, Mass., at the farm of L. F. Baldwin, on Friday, Nov. 15, 1912. The tanks were placed out in the open, well away from

*From a report made to the Factory Mutual Laboratories (under the direction of the inspection department, Associated Factory Mutual Fire Insurance Companies).

†Chemical Engineer, Factory Mutual Laboratories, 31 Milk St., Boston, Mass.

any buildings. The weather conditions were fair, although the sky was overcast. The wind blew from the northwest at a velocity of from some 14 to 19 miles per hour.

The sawdust was applied by means of a snow shovel having a steel blade 11 in. wide and 15 in. long, and provided with a handle 4 ft. long. The fires were all extinguished by the writer except in one case. [From the log of the 16 tests the following typical cases have been taken.—ED.]

TEST NO. 1.—Small Tank Containing 2 in. of Stanley Lacquer.

Time	Remarks.
2:20:00	Fire started.
2:21:03	Sawdust applied.
2:21:28	Fire extinguished with 2½ shovels of soft-wood sawdust in 25 sec.

TEST NO. 3—Small Tank Containing 5 in. of Stanley Lacquer, Left From Previous Tests After Sawdust Had Been Removed From the Surface.

2:40:00	Fire started.
2:41:18	Sawdust applied.
2:41:53	Fire extinguished with two shovels of dry soft sawdust in 35 sec.
	In this test some of the lacquer which had leaked out on to the ground ignited near the tank, but was readily extinguished with a small amount of sawdust in about 10 sec.

TEST NO. 4—Small Tank Containing 4 in. of Lacquer Left From the Previous Tests After Sawdust Had Been Removed From the Surface.

2:50:00	Fire started.
2:51:19	Sawdust applied.
2:51:29	Fire extinguished with ¼ shovel of mixture of bicarbonate of soda and sawdust in 10 sec.

TEST NO. 6—Small Tank With 3 in. of Stanley Lacquer Left From Previous Tests, After Sawdust Had Been Removed From the Surface.

2:58:00	Fire started.
2:59:03	Sand applied.
3:00:58	Fire extinguished with nine shovels of dry sand in 1 min. 55 sec. The tank was over half full of sand before the last flame disappeared.

TEST NO. 9—Soft Pine Platform 5 ft. 2 in. Square Provided With Rim Raised 2 in. on All Four Sides; About 2 gal. of G. E. Lacquer Uniformly Spread Over the Surface.

3:30:00	Fire started.
3:30:45	Sawdust applied.
3:31:38	Fire extinguished with three shovels of soft-wood sawdust in 53 sec.

TEST NO. 10—Same Platform As in Test No. 9, With About 2 gal. of G. E. Lacquer Spread over the Surface.

3:35:00	Fire started.
3:35:36	Extinguisher applied.
3:36:32	Fire extinguished by means of a 3-gal. chemical extinguisher, but with some difficulty, in 56 sec. In this test if the stream from the extinguisher had not been carefully sprayed, or if the platform had not been provided with a rim, it is probable that the force of the stream would have spread the lacquer all over the ground.

TEST NO. 11—Middle Tank Containing 1⅜ in. of G. E. Lacquer From Test No. 8, After Sawdust Had Been Removed From the Surface.

3:40:00	Fire started.
3:41:32	Sawdust applied.
3:41:45	Fire extinguished with two shovels of hard-wood sawdust in 13 sec.

TEST NO. 13—Small Tank Containing 1¾ in. of Motor Gasoline

4:20:00	Fire started.
4:20:38	Sawdust applied.
4:20:50	Fire extinguished with two shovels of a soft-wood sawdust in 12 sec. Fire in a small amount of gasoline which leaked out on to the ground was easily extinguished in a few seconds with a small amount of sawdust.

TEST NO. 16—Middle Tank Containing 2¾ in. Gasoline.

4:40:00	Fire started.
4:40:50	Dry sand applied.
	Four shovels of sand were used, but as they had absolutely no effect, the fire was finally extinguished with eight shovels of sawdust in about 56 sec.

CONCLUSIONS

In view of these tests, the following conclusions appear warranted.

(1) Sawdust, if spread over the surface, will readily and successfully extinguish fires of inflammable liquids, particularly lacquer, when contained in moderate-sized tanks, or small fires in these liquids on the floor. Fires in gasoline in up to the middle-sized tanks, were extinguished without difficulty, but there may be some question as to whether sawdust would have worked equally well in larger tanks.

The efficiency of sawdust is undoubtedly due to its blanketing action in floating for a time upon the surface of the liquid and excluding air. Its efficiency would be greater on viscous liquids than on thin liquids, since it would float more readily on the former. Sawdust itself is not very easily ignited and it burns without flame; the embers are not sufficient to re-ignite the lacquer.

(2) The character of the sawdust, whether from soft or hard wood, appears to be of little or no importance.

(3) The amount of moisture contained in the sawdust is apparently not a factor. The dry sawdust which was used in some of the tests was prepared in order to represent the condition in which sawdust might be found after having been stored in a heated mill for some time. This material, however, was evidently as efficient as the untreated sawdust.

(4) The depth of lacquer in the small tank was of no importance.

In the largest tank, on the other hand, it is quite possible that with greater depths than those tried, it might have been much more difficult to extinguish the fires. Tests at greater depths were not tried on account of the large quantity of lacquer required. This is not as important as might seem at first thought, because the average lacquer tanks in mutual-insurance mills are about the same size as the smallest of those employed in these tests.

(5) Sand is not satisfactory for extinguishing fires in lacquer tanks because being heavy it sinks to the bottom and does not have the blanketing action of sawdust.

(6) The sawdust can best be applied by means of a long handled and light, but substantial, shovel with a large blade. The long handle is necessary since in some cases the fires are too hot to work at close range.

(7) The admixture of sodium bicarbonate very much increases the efficiency of the sawdust, as shown both by the shortened time and decreased amount of material necessary to extinguish the fire. The effect of the carbon dioxide was clearly noticeable in the tests in that the flames occasionally made an effort to shoot sidewise and up from under the blanket of gas. The bicarbonate will decrease possible danger from the presence of sawdust in mills. It would be very difficult, if not impossible, to ignite the bicarbonate-sawdust mixture by a carelessly thrown match, etc.

If difficulty arose from the caking of the bicarbonate it could be easily overcome by the addition of 10% by weight of iron ore.

The Relation of a Pure Water-Supply to Chronic Intestinal Tract Infection*

BY NICHOLAS S. HILL, JR.,† AND LEON R. WHITCOMB‡

One of the common if not the most common result of chronic intestinal-tract infection is auto-intoxication. It is not the purpose of the authors to present a history of auto-intoxication, but rather to outline its effect upon the body and to suggest that one cause of auto-intoxication may be the constant drinking of impure water. If this hypothesis is true, then we have found one rational explanation for the increased human resistivity following the substitution of a pure water for a polluted water and, therefore, the cause for the decrease in the general death rate following such a change.

The symptomology of auto-intoxication which is presented here is drawn largely from the works of Metchnikoff, Dr. A. Combe, of the University of Lausanne, Switzerland, and Dr. C. A. Herter, of Columbia University, New York City.

AUTO-INTOXICATION AND ITS EFFECT ON THE GENERAL HEALTH

Dr. Combe defines intestinal auto-intoxication as the toxaemia caused by qualitative or quantitative alterations in a normal digestion. By normal digestion is meant the digestion of a normal man produced by the enzymes or the bacteria in the stomach and intestines. Auto-intoxication may also be defined as a toxaemia caused by poisonous substances, which are formed through the influence of the vital processes of the body. Such substances are termed "toxic substances" or "toxic compounds."

Certain classes of bacteria perform a legitimate function in the process of digestion, and while their presence may not be absolutely necessary, yet under normal conditions their presence is at least not detrimental. Under certain conditions, however, the bacterial action is extended to the production of hydrogen sulphide, lactic, butyric, propionic acids, indol, skatol, phenol, paracresol and other substances derived from the processes of fermentation and putrefaction. These compounds may be produced by the introduction of bacteria not normal to the intestines, but which, when planted there, gain a firm lodgment and carry on the work of putrefaction. The toxic compounds may also be increased by an increase in the number of bacteria normal to the intestine. In fact, any bacterial condition in which the number, varieties and microbic associations overbalance those influences provided by nature to prevent the formation of toxic substances detrimental to the human organism may produce auto-intoxication.

The substances introduced as food into the alimentary canal, which are most susceptible to putrefaction are the highly nitrogenous compounds. It is the aromatic bodies produced by the action of bacteria upon these proteid matters, which cause auto-intoxication. These products, some of them but slightly poisonous individually and in the quantities normally present, when present in excessive quantities produce the most deleterious effects upon the human system. Fortunately, the body is capable of gradually accustoming itself to the presence of these toxic substances and even organizes means of defense against them.

The ability of the human organism to adjust itself to the presence of toxic substances derived from the intestines is limited, and it may be overcome by the formation of excessive quantities of the toxic compounds. It is also impaired by other means, such as a severe cold, by overwork, or by some disturbance of the nervous system. It also varies greatly with the individual.

In order to reach the large intentine, bacteria admitted in food to the mouth must pass through the stomach, and, under usual conditions, remain in the stomach for a period of time. Here they are subjected to the action of the stomach fluids, which are acidified with hydrochloric acid. Since most vegetative forms of bacteria are destroyed by hydrochloric acid, only a small per cent. of the number of bacteria entering the mouth ever reach the intestines under normal conditions. If, by some derangement of the digestive system, the stomach contents become weakly acid or alkaline, increased numbers of bacteria are permitted to enter the intestines directly. Liquids, such as milk or water, for example, dilute the stomach juices and also pass through the stomach rapidly. Thus it is possible even in the normal condition of the stomach for large numbers of bacteria to pass into the intestines.

When the bacterium reaches the intestine, it must begin at once a battle royal for supremacy over other varieties of bacteria. It must align itself with one of two groups, the putrefactive group, or the lactic acid producing group. Some bacteria, however, are capable of joining either group, and will align themselves with the group which appears to predominate. For example, B. coli is capable of living aerobically and producing acid or of living anaerobically and aiding in the putrefactive processes.

When the acid-producing bacteria predominate in the intestine, and the contents of the intestine are therefore acid, there is little opportunity for auto-intoxication, since the toxins causing the disturbance can only be produced under strictly anaerobic, putrefactive conditions. It is, therefore, only with these latter effects that we are interested in this discussion. If, for any reason, the putrefactive organisms predominate in the intestines, toxic substances, such as indol, skatol, putrescin, cadaverin, methyl mercaptan, may be formed.

If unprevented, these toxines, together with the bacteria themselves, will enter the portal vein and eventually the circulatory system. Under normal conditions, however, they do not reach the major circulatory system [being repelled or neutralized by various agencies outlined in the paper.—Ed.] No one of these agencies necessarily performs the entire work of destroying the toxines, but each does a part. When one defense begins to fail, the others are forced for a time into greater activity, ... finally the antitoxic glands become altered and fail to contribute the necessary amount of antitoxin to the blood. It is then possible for the poisonous compounds to pass unchanged from the intestinal tract into the major circulatory system where they produce various symptoms of disease, according to their nature and quantity. They may effect: (1) the heart; (2) the arterial blood pressure; (3) the respiratory system; (4) the nervous system; (5) the general nutrition; (6) the urinary system.

THE RELATION BETWEEN IMPURE WATER AND AUTO-INTOXICATION

Thus far, we have only hinted at the relation between impure water and intestinal tract infection, one of the most important results of which is auto-intoxication. We have stated that among other causes of the breakdown of the defensive organs of the alimentary system is that due to a large increase in the putrefactive bacteria entering the intestine in the food.—[Finality has not been reached but] as a general thing, the authorities consulted concur in the belief that the anaerobic bacteria are chiefly concerned and that the anaerobic bacteria most prominently mentioned have been of the spore forming variety, included in which are the B. aerogenes capsulatus, B. enteriditis sporogenes, B. putrificus, B. anaerobicus alcaligenes.

In considering the possible effect of polluted water in intestinal tract infections, it must be remembered that the secretion of the gastric juices is most active at the time that freshly digested food is in the stomach and, therefore, while uncooked food may be the most potent factor in the introduction of foreign bacteria into the digestive tract, the bacteria thus ingested are subjected to the maximum disinfection produced by the gastric juices. When the stomach is idle, the production of gastric juices is very slight and it is under these conditions that water is regularly and frequently taken. It is to be remembered that liquids, and particularly water, pass more rapidly from the stomach to the lower intestines than do solids and, therefore, the time element, which is an important factor in the destruction of foreign bacteria, is materially lessened, and, lastly, that the percentage of water present in the intestines materially influences the character of the bacterial action in the intestine.

If, therefore, the supply of putrefactive bacteria through the agency of water is constant, though small in number, and the diet of the person inbibing impure water is favorable to the putrefactive bacteria, it is not unreasonable to assume that these small numbers will in time, or under accidental conditions, produce anaerobic putrefaction and eventually intestinal tract infections and the resultant auto-intoxication.

So long as bacteria which are concerned in chronic intestinal tract infections are evacuated, so long will these bacteria be present in greater or lesser quantities in sewage-polluted water, and we have a repetition of the same phenomena, which are present in the causation of typhoid fever and other acute gastro-intestinal disturbances. As a matter of fact, those bacteria which have been most prominently mentioned in connection with chronic intestinal-tract

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†Consulting Engineer, 100 William St., New York City.

‡Chief Chemist and Bacteriologist, Laboratory of Nicholas S. Hill, Jr., 100 William St., New York City.

infections, and which are generally of the spore-forming variety, have frequently been isolated from the water-supplies of various cities.

Nearly everyone in the medical world today is more or less familiar with the theorem formulated by Hazen and the so called Mills-Reincke phenomenon. Hiram F. Mills, member of the Massachusetts State Board of Health, and Chief Engineer of the Locks and Canals on Merrimac River, observed that shortly after the introduction of a filtered and purified water-supply in Lawrence, there was a marked decrease, not merely in the death rate from typhoid fever, but also from other diseases. At the same time Dr. J. J. Reincke, Health Officer of Hamburg, Germany, observed a similar effect on the death rate of his city following the installation of a purer water-supply. From these observations, together with observations made by him in the cities of Troy and Albany, Allen Hazen evolved a theorem which he states as follows: "Where one death from typhoid fever has been avoided from the use of better water, a certain number of deaths, probably two or three, from other causes, have been avoided."

Prof. W. T. Sedgwick and J. S. MacNutt have made further studies of the Mills-Reincke phenomenon. In addition to the cities above cited, they examined the death rates of Lowell and Binghamton, and found that following the introduction of a purer water-supply in these cities, there was a decrease in the number of deaths due, not only to typhoid fever, but to other causes. They found that the decrease in death rate was particularly noticeable in such diseases as diarrhœa, cholera infantum, other gastro intestinal diseases, pneumonia, pulmonary tuberculosis and bronchitis. Furthermore, they noted an apparent improvement in the general health of the community, not traceable to the reduction in these diseases.

Of the diseases just mentioned, it will probably be admitted that the causative factor in the production of diarrhœa, cholera infantum, pneumonia and pulmonary tuberculosis may be bacterial. We will venture to state that most gastro-intestinal diseases have their origin through the agency of bacteria. It will also be admitted by most that typhoid, cholera, diarrhœa, cholera infantum, dysentery and other acute gastro-intestinal diseases may be water borne. There are some who claim that pulmonary tuberculosis may be conveyed through the medium of water. So far as this paper is concerned, however, the most interesting fact here presented is that all of the acute gastro-intestinal diseases have, at one time or another, been attributed to water. If this be so, why may not chronic intestinal tract infections be water borne?

Two hypotheses have been suggested to explain the improvement in the general health tone, aside from those diseases which are known to be specifically water borne. One credits the reduced death rate to the greater human resistivity following a reduction of the organic matter, or filth, in a water-supply, but it has never been definitely shown that filth per se, minus infection, will produce disease. Filth may be deleterious and harmful and tend to reduce the vital resistance of the body, but the amount of organic matter or filth, which may be present in a drinking water, which is inoffensive to the taste and smell, is so small that its pathological significance is minimized, if not eradicated.

The other hypothesis is that the improvement is due solely to the elimination of bacteria which may be causative of disease, but whose etiological significance is not now known. We know that the elimination of specific bacteria, which are now recognized as the etiological factor in specific disease, will reduce specific diseases such as typhoid and cholera. It may be that the removal of many other bacteria not now recognized as the etiological factor in the causation of disease may be accountable for the reduction in the general death rate as noted. As a matter of fact, the flora of the intestinal tract or the human faces, and the results of these which are not at this date associated with disease. The function of these bacteria is not known and the variety of species present in the intestines of man is not probably generally appreciated. In fact, the consensus of opinion of the writers of the present day is that the species of bacteria present in the intestines of man is very limited.

Our studies have carried us into a tabulation of the various species of bacteria which have been isolated from the intestinal tract or the human feces, and the results of these findings are included in a table which we present with this paper [omitted here.—Ed.].

A study of this table, conjoined with the knowledge that a year seldom passes without establishing the direct connection between a specific disease and a bacterium formerly unassociated with disease, will lead one to concede that many of the bacteria listed in this table, but not now associated with disease, may possess the potential ability to produce disease.

The authors believe that the reduction in the general death rate, following the introduction of pure water, which has been noted, can be attributed to a reduction in bacteria rather than to a reduction of filth. The correctness of this view is supported by a consideration of the relation of bacteria to intestinal-tract infections, which may not of necessity be acute, as in the case of diarrhœa, dysentery, enteritis and typhoid, but which may develop a condition of toxaemia, which affects the general health tone and thereby increases susceptibility to other diseases, not alone those at present associated with bacteria, but those unassociated with them as well.

That there are many cases of intestinal-tract infection at the present time, which pass unheeded and unnoticed, is the consensus of opinion of a number of eminent scientists and physicians who have made a special study of these infections. Chief among the results of chronic infection is the so called auto-intoxication, which is another name for many forms of indigestion or derangement of the processes of digestion.

It has been found when careful studies have been made that more people are suffering from intestinal-tract infection and auto-intoxication than is usually supposed, and we believe, if a careful investigation of the subject were made, it would be found that many people in our congested communities are suffering from this disturbance. When a person is suffering from impaired digestion, affected heart, a diseased condition of the kidneys, or a nervous breakdown, conditions which are often the result of auto-intoxication that person must naturally be in a much more susceptible condition toward other diseases. Moreover, the problem of the prevention of disease has only been partially solved when the infections of chlera infantum, dysentery and typhoid fever are broadly checked by modern sanitary measures. There still remains the more elusive task of preventing the recurrence of the severe chronic infections in the digestive tract. The acute infections like dysentery and typhoid are so numerous and obtrusive in their manifestations that it is impossible to overlook them, but chronic infections are obscure in their manifestations and seldom are found in epidemic form. Hence, they pass unnoticed. The injurious effects of the chronic infections are none the less real.

It is not the intention of the authors to ride a hobby or to insist upon a theory to the exclusion of other theories. We have had entirely too much of this in modern sanitation, but it seems wrong to assume that various morbid manifestations are inevitable or inherited. The effects of chronic poisoning of gastro-enteric origin are understood by few persons, for it must not be forgotten that in addition to reduced physical resistivity, these enterogenic intoxications of the nervous system may be extremely detrimental to character and contribute to complicate and mar the finer human relations. They entail a severe economic loss to the communities in which they occur through the partial failure of performance resulting from the reduced efficiency of the individual suffering therefrom.

It would seem that a proper regard for the inestimable benefits to be achieved by any process which will aid in the reduction of chronic intestinal-tract infections will add to the significance to be attached to the reduction in the general death rate following the introduction of such a process, and a proper regard for these infections will tend to minimize the tendency to over-value results achieved by such a process as shown by an individual study of the reduction in a specific disease, such as typhoid. The time has come when the sanitarian should judge of the value of a process, not by the reduction in the death rate along specific lines alone, but also by its effect on the general health tone of the community. A proper appreciation of the importance of the enterogenic intoxications will certainly tend to eliminate the preponderating value placed upon the prevention of epidemics, one might say almost to the exclusion of a consideration of deleterious endemic conditions.

NEW WORK FOR THE SANITARIAN

The sanitarian has been so eminently successful in the prevention of epidemics that he should now turn his attention to the chronic affections which so seriously impair the usefulness and comfort of a great portion of our population. It is chiefly for the purpose of focusing attention in this direction that this paper is presented, though the theory outlined suggests a rational explanation for the "Hazen Theorem."

[Following the original paper there was a lengthy table of "Bacteria of the Intestinal Tract," giving names, whether obligate or facultative anaerobes, and citing authorities; also a long list of references to books and articles on intestinal bacteria.—Ed.]

EDITORIALS

There is a story with a moral to it in the annual report of the Panama Railroad Co. just issued. It will be remembered that all the capital stock of this company is owned by the United States Government. The company's directors are all officers of the army or navy or connected with the Panama canal work. The report states:

> A serious strike among marine firemen, oilers, water tenders, sailors and petty officers in New York Harbor developed about the close of the fiscal year, that threatened to completely tie up the Panama Railroad Steamship Line. As it was inadvisable that a Government-owned line employ strike-breakers, our ships were all manned for one round voyage by enlisted men from United States war vessels then in New York. Our sailing dates were thereby protected, serious loss to the company averted, and great inconvenience and discomfort to the officials and employees of the Commission and railroad on the Isthmus, through lack of communication and supplies, prevented.

It will be recalled that when the French nation was brought to a crisis by a strike of all the employees on the Government railways, the Government met the situation by ordering all the employees to undertake military service, and continue the railway operation as enlisted men.

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More Discussion of the Status of the Engineering Profession

Evidence that the subject discussed in the leading editorial in our issue of Jan. 2, "The Status of the Engineering Profession," is uppermost in the minds of engineers holding high positions in the profession, as well as those in the lower ranks, is furnished by the remarkable discussion which took place at the December meeting of the American Institute of Consulting Engineers. The announced subject for the meeting, we believe, was the relations between the engineer and the contractor, but those who took part in the discussion devoted their chief attention to the broader subject, the status of the engineer.

The papers by Lewis B. Stillwell and Samuel Whinery, which were read at that meeting, were printed in our last week's issue, and have been read with interest, we doubt not, by a majority of our readers. When an engineer of the long experience and high standing of Mr. Whinery expresses the opinion that if certain present tendencies are allowed to continue unchecked, engineering as a profession will cease to exist, it is certainly time that engineers gave careful study to the conditions under which they are carrying on their work.

Similarly, when so eminent a consulting engineer as Mr. Stillwell asks the question in all seriousness whether the consulting engineer in a standardized industry is not a middleman who should be eliminated, there can be no doubt that the status of the engineering profession is a matter deserving grave consideration.

It is distinctly a hopeful sign, however, that these serious questions are being taken up in earnest by men at the head of the profession. It is to them that the younger engineers look, and properly look, for leadership and counsel. The extent of the dissatisfaction among the younger members of the profession, and in fact among men no longer young who are working under unsatisfactory conditions, is increasingly evident. The strong movement to bring about legislation restricting the practice of engineering is one evidence of the current dissatisfaction. Another hint as to the agitation which is going is furnished by a letter before us, received recently from a prominent engineer in the West. We quote from its contents as follows:

> Engineers have labored hard for years to establish their standing as professional men, and today people understand that we are highly educated, and that we should be ranked as the equal in intelligence of physicians, surgeons, lawyers, ministers and editors. It has been a long, hard pull from the mechanic class to the position in which we now stand in the public mind, but recent events have alarmed me, and it looks as if we are soon to experience a severe shock.
>
> I have been informed that within the past few weeks the American Federation of Labor has granted a charter to a civil engineers' union near New York, and is considering an application from a body of young engineering graduates in Chicago, who are organizing a similar union. Two young fellows have been in to see me about it and went out with their ears burning. They had the nerve to think I might join them and wanted me to be the first President.
>
> These boys told me that if the unions are organized and a string can be formed across the country, they will insist upon all the plans and details bearing the union stamp; and if they do not, then union workmen will not do the work of manufacturing or erecting structures on which union engineers have not been employed as designers.
>
> They say that no man objects to paying a dollar an hour to bricklayers who cannot read and write, but $75 per month is considered good pay for men who supervise the work of the bricklayers and are held responsible for the work being done right.
>
> They say the engineering schools still advertise for students and send articles to daily papers telling of the high pay given to engineers, etc., so that thousands of boys go to engineering schools who would otherwise have learned a trade.

If to some engineers in active and successful practice, the formation of trade unions in engineering seems an impossibility, it may be well to reflect on the fact that other occupations in which executive ability and originality are both requisite have already been unionized. The strike of the reporters and sub-editors of New York City newspapers published in foreign languages during the present month is an illustration of the extent to which the trade-union movement has already been carried.

We shall not attempt, at this time, to discuss the proposition of transferring the engineering profession into a trade union. We may remark, however, that so far as the fixing of standard rates of fees for professional work is concerned, action of that sort has already been taken by some of the engineering societies composed of men of the highest standing in the profession. It is, perhaps, no very long step from such measures to the adoption of standard rates of compensation for employees working for salaries or wages in the drawing office, the shop, or the field. It is perhaps worth serious consideration whether some action of this sort might not be taken which would forestall any movement for organizing trade

unions among those working in various subordinate branches of engineering.

There is a great public need at the present day in all branches of industry for men who have the natural ability and technical training to be competent as leaders. We do not believe that the best apprenticeship for such leadership during the early years of work will be gained through membership in a trade union.

The Perils of Navigation on the Hudson Bay Route

Many of our readers will recall that immediately after the "Titanic" disaster last summer, we called attention to its significance as an object lesson with respect to the dangers of navigation on the proposed Hudson Bay route to Europe. We then showed in detail the perilous ice conditions which steamers attempting to enter Hudson Bay during the short period of navigation, from about the middle of July to the middle of September, must encounter. Not only is there danger from icebergs, but from heavy Arctic field ice and from fog, which is present over these far northern seas during a large part of the short summer.

Dangers of this sort are to be met much farther south, on the Canadian transatlantic route to St. Lawrence ports. A recent issue of the *Toronto Globe* says:

D. C. Valentyne, a member of the Montreal Harbor Commission, addressing the Toronto Canadian Club a few days ago, told his audience that the insurance charges on line steamships navigating the St. Lawrence are very much higher than those on ocean steamships resorting to United States ports, and that the rates imposed on tramp steamships are higher still, so much so that these vessels have been driven entirely off the route.

The *Globe* urges the establishment of a Canadian marine-insurance company and a better system of pilotting for the St. Lawrence. The latter is very likely needed; but the fact cannot be denied that there are many dangers in navigating the ocean route terminating in the Gulf of St. Lawrence, and that these dangers must necessarily be represented by increased rates of insurance. If one were to plot upon a chart the marine disasters which have occurred during the past dozen years along and near the St. Lawrence route, the showing would not be encouraging to those who argue for lower rates of insurance there.*

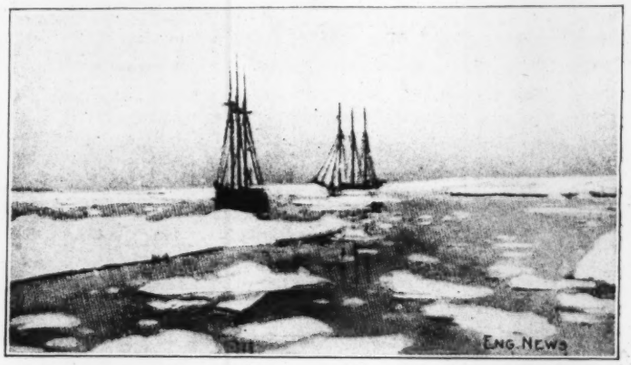
But if marine-insurance rates are so high as to divert tramp steamships from the St. Lawrence route to United States ports, what rate would marine underwriters fix to compensate them for the risks to tramp steamships which should attempt to enter Hudson Bay to take part in the grain traffic during the few weeks of the year when navigation is possible?

We have just received the report of the Department of Naval Service of the Canadian Government for the last fiscal year, and find in it a notable account of the work of the marine survey on Hudson Bay and Strait.

The report describes the voyage of the Canadian Government survey steamer "Minto," with two schooners and the coaling steamer "Beatrice," which left Sydney, Nova Scotia on July 18, 1911, to sail up the coast of Labrador and pass through Hudson Strait to Port Nelson and Port Churchill, in the southern part of Hudson Bay. The account of the voyage reads much more like the story of Peary's voyage in the "Roosevelt," in search of the North Pole, than like the log of any voyage for commercial purposes.

The vessels proceeded up the Labrador coast, experiencing much fog and heavy weather, and passing many scattered icebergs. On July 25, about 25 miles off Cape Mugford, Labrador, in lat. 58°, the vessels encountered field ice in such quantities that the captain of the "Beatrice" refused to proceed and finally turned back, leaving the "Minto" with the two schooners to go on alone. We quote extracts from the report as follows:

It is impossible to state how far this ice extended off shore, but from aloft no clear water could be seen ahead or to the eastward. . . . . During the following night a field of very heavy Arctic ice was encountered and we lay to until daylight, not caring to risk entering it. On July 27, we were off Cape Chidley. At 4:30 a.m., the tow line was parted by fouling a large pan of ice, although the "Minto" was speeding very slowly. . . . . At 4 a.m., on July 26, we entered another flow of Arctic ice, probably from Gabriel Strait. On clearing this ice the speed was increased about 8 knots until noon. This also proved to be Arctic ice, some very large pans closely packed together in places. Fair leads could



TWO SCHOONERS OF THE CANADIAN GOVERNMENT HUDSON BAY SURVEY EXPEDITION IN HUDSON STRAITS, JULY 28, 1911

be picked out from the masthead, but there was no clear water visible. At about 1:30 p.m. we glanced off a large pan, which it was impossible to avoid and the starboard anchor caught, tearing away the hawsepipe and considerably damaging the plates nearby. On examination it was found that the hawsepipe was completely shattered and must be removed. An old iron door was used for a patch, the most was made of everything available. At this time one of the schooners was reported to be damaged and taking water fast. The fore foot had been carried away by ice. The schooner was brought alongside and cleared of water by steam pumps. A spare foresail was then stretched under the bow and drawn up as tightly as possible on either side when quantities of ashes were thrown into the sail from the "Minto" and the suction produced by the leak almost stopped it in a few hours. This was most satisfactory, as the situation began to look serious. The engineers worked all day at repairs. The ship drifted about 13 miles to the northwest in 24 hours and we were surrounded again by Arctic ice in very large pans, and in fact small icebergs.

Monday, July 31, heavy ice was drifting past. The crew was engaged in trimming coal aft to bring the ship up as much as possible in better shape for the ice. Aug. 1 the damaged schooner was beached in Wakeham Bay and the damage was repaired as well as possible with the tools and material at hand.

On Aug. 3, about midnight, we ran into a field of Arctic ice, which had come down from Fox Channel. The weather was very thick and the ice closely packed so we made fast to a large pan, as it was impossible to pick out any leads through which we might make a safe passage. On Aug. 4, the fog was very dense and we were hove to all day, not considering

*The Furness line steamer "Florence" was wrecked on the coast of southern Newfoundland, on Dec. 20, and 22 of the 27 men on board were lost.

The transatlantic steamer "Uranium" went on the rocks in a fog nine miles from Halifax, Nova Scotia, on Jan. 12, and had to transfer her 839 passengers to vessels sent to her rescue.

it safe to make a move under the conditions. At sundown, the fog lifted, we were lucky enough to completely clear the ice before the fog closed in again. This was the last ice met with, for which I was very thankful. We arrived at Port Churchill on Aug. 7. While crossing Hudson Bay the weather was fine, but foggy.

This is the official report to the Canadian Government describing the seas through which vessels will have to pass if the commercial navigation of the Hudson Bay route is ever to take place. The perils of such navigation to such small vessels as engage in whaling, fishing or Government explorations in these latitudes are evident enough; but the peril would be even greater to the far larger vessels which would be required if grain were to be carried to Europe by this route in the quantities necessary to justify the building of the Hudson Bay Ry.

And as we have shown above, this peril, measured in dollars and cents by the marine underwriters in the form of insurance would inevitably be so heavy as to more than offset the claimed commercial advantages of the Hudson Bay route, on the strength of which the Canadian Government is attempting to build the Hudson Bay Ry.

❋

Overloading the Interstate Commerce Commission

Everybody knows that in carrying on any industry, if a workman is given more to do than he can perform in a given time, he must slight some of the work. The same thing is true of the man higher up, all along the scale from foreman to president. If a man is given a larger number of responsibilities than he can properly discharge, he will have to slight some of them. One of the reasons why many of the great industrial combinations are breaking down and failing to obtain the efficient and economic operation which was prophesied for them when they were organized, is that the task of looking after all the varied activities of such a huge affair proves too great for the capacity of even extraordinary men.

Everybody recognizes, as we have said, this situation in private business; but when it comes to public business our lawmakers have the habit of loading a public official with responsibilities without a thought as to whether he has any spare time which he can give to these new tasks. Mayors of cities and governors of states are placed on all sorts of boards and commissions *ex-officio* until they would require 49 days in each week, instead of 7, were they to really discharge all these duties in something more than a perfunctory way.

About the most glaring example at the present time of this tendency to overload public officials is found in the Interstate Commerce Commission. This body of seven men, according to its annual report just issued, received during the past year 6550 complaints of informal nature which had to be taken up with carriers by correspondence and an adjustment reached if possible. It received 6009 applications from carriers for leave to refund to patrons money collected in accordance with tariffs which for one reason or another were unlawful. It received nearly 2000 applications for relief from provisions of the fourth section of the Act. There were 189 proceedings instituted before the Commission to suspend the operation of tariffs which had been filed but had not taken effect. There were 755 formal complaints filed with the Commission during the year. The Commission conducted during the year 1154 hearings, at which about 125,000 pages of testimony were taken. The Commission has of its own motion undertaken investigation of the rates of express companies, and it has now in progress investigations on substitution of tonnage in transit, allowances for terminal railroads, weighing of freight, issuing of passes, bills of lading, private cars, rates on anthracite coal, etc. The Commission conducts a tariff bureau with which 108,000 tariff publications were filed during the year. The Commission has charge of suits brought for infringement of the Interstate Commerce law, under which 93 indictments were returned during the year, and many pages of its annual report are devoted to a review of various litigation in which the Commission is taking an interest as representing the public.

Uniform systems of accounts for railways, electric railways, express companies, pipe lines, sleeping-car companies, telephone, telegraph and cable companies, water carriers and gas and electric corporations have been prepared by the Commission. The Commission carries on examinations of accounts of the various concerns under its jurisdiction, and undertakes disciplinary measures where its system of uniform accounts is not followed. The Commission further collects the statistics of the railways of the United States, has charge of the investigation of railway accidents, the enforcement of the laws relating to safety appliances, the use of locomotive ash pans, the hours of service of employees, and the inspection of locomotive boilers.

It will be admitted, without question, that these responsibilities are quite enough to lay upon the shoulders of any seven men, no matter how great their capabilities for work. The end, however, is not yet. Congress, in its anxiety to regulate every act of the railways from least to greatest, has acquired the habit of tacking on to each new proposed law a section placing responsibility for its enforcement upon the Interstate Commerce Commission. For example, the Adamson Bill, which passed the House of Representatives on Dec. 5 and is now before the Senate, requires the Commission to undertake the valuation of the property of all the railways of the United States, by means of an inventory "to be made by such engineers, experts and other assistants as may be necessary." Another bill now pending in the House of Representatives forbids the use on any railway, after Jan. 1, 1915, of any car in passenger service "not made of steel with vestibule platforms and all modern appliances," whatever the latter may mean. The Interstate Commerce Commission is to be charged with the enforcement of this law and is given authority to suspend its enforcement in cases where it may deem wise. Another pending bill requires all common carriers to equip their locomotives with headlights "of not less than 1500 candlepower, measured without the aid of a reflector." The Interstate Commerce Commission is likewise given authority to enforce and suspend the operation of this law in its discretion. A resolution, introduced into the House on Dec. 10, requests the Commission" to investigate the management of repair shops of railroads throughout the United States in respect to their efficiency in all their branches, and report its finding to the House." The same resolution also orders the Commission "to investigate the management of railroads in the United States with respect to car shortages and car storages and the manner of manipulation of the same."

These are but samples of the many schemes now under

consideration by would-be reformers in Congress and elsewhere, which propose to further increase the burdens and responsibilities laid upon the Interstate Commerce Commission. As we remarked above, when a man or set of men is overloaded with responsibilities, some of his work must suffer. The Interstate Commerce Commission already has laid upon it a far greater amount of work than it can efficiently perform.

It is not the personal welfare of the members of the Interstate Commerce Commission that makes its overloading a matter of greatest importance. We as a nation have embarked on the largest experiment ever undertaken in Governmental regulation of public utilities. It is important that this experiment shall succeed; for if it does not succeed, indications multiply that we shall be driven to the far more radical experiment of Government ownership and operation.

But in order that Governmental regulation shall succeed, it must be governed by the same business principles that control the administration of any private business. It is just as necessary that the Interstate Commerce Commission shall do efficient work as it is that efficiency shall prevail in the railway repair shops; and neither the Commission nor the repair shop can operate with good efficiency when congested with work beyond their capacity.

LETTERS TO THE EDITOR

The Cape Cod Canal

Sir—In your issue of Jan. 9, 1913, in the article on the Cape Cod Canal, I find this statement,

> From Buzzards Bay the passage into Long Island Sound is easy and can be made in all kinds of weather without danger.

It is a well known fact that Point Judith, R. I., is a terror to coastwise shipping. Between 1880 and 1903 there were 1016 marine disasters on the Atlantic coast between Cape Cod and Long Island Sound, 458 of which occurred between the entrance to Buzzards Bay and the eastern entrance to Long Island Sound.

The Cape Cod Canal will save the trip around Cape Cod, but "in all kinds of weather" the trip around "Pint Jude" is anything but pleasant and is not "without danger."

RALPH F. RHODES.

Newport, R. I.,
Jan. 10, 1913.

[We are aware that rough seas are often met with around Point Judith, which not infrequently give serious trouble to navigators of barges and schooners. What the writer had in mind was vessels of a more seaworthy type, which can go around Point Judith in safety, when rounding Cape Cod would be highly dangerous.—ED.]

Effect of Moisture on the Strength of Concrete

Sir—Referring to the letter on "Effect of Moisture on the Strength of Concrete," in ENGINEERING NEWS, Jan. 16, 1912, p. 127, I wish to state that I have received permission from some clients to make public some bare facts relating to experiments performed by me in 1908. This communication is read by them and approved before being sent to you and I am grateful that this much is permitted.

We made a number of blocks of concrete from one batch. They were in the form of slabs 2 in. thick, with embedded ½-in. bars. In some blocks the bars were round and smooth and in others they were square and twisted. One-third of the slabs were placed in the roof of a small shed where the under side would never be wet and where the temperature was practically that of any unheated building with thin walls of boards, with cracks between. One-third of the slabs were placed in a room where they were never wet and where the temperature possibly was never less than 125° F., generally somewhat higher. One-third were suspended in water. The steel projected only from one end and the slabs were suspended by wires attached to the projecting ends of the steel.

Pulling tests were made at the end of 3, 6, 9, 12, and 18 months. Further details I am not permitted to give but the conclusions reached were as follows:

1st. Deformed bars of almost any type are preferable to plain bars when same are not bent at the ends or are not supplied with plates or other means for mechanical anchorage. I have never used plain bars since that time in my designs.

2nd. Concrete constantly exposed to a drying action shows much less bend, or adhesion, than concrete placed where it is alternately wet and dry. Concrete floors should be frequently scrubbed and concrete ceilings can be sprinkled with advantage from time to time. If a coat of watertight paint is applied to a ceiling, then the floor above should be wet often to keep the concrete from becoming too dry. A practice lately mentioned of putting steam pipes in concrete floors should be condemned.

3rd. The adhesion of concrete to steel is weakened by continued submergence and the use of high stresses (especially high bond stresses) in thin reservoir and tank walls is not good practice.

4th. Concrete used for reinforced-concrete tank walls should be of the very best and hardest stone procurable.

I hope some professor of engineering will duplicate the foregoing described tests in the college laboratory and make the results public.

ERNEST MCCULLOUGH.

Monadnock Block, Chicago, Ill., Jan. 18, 1913.

Bituminous Filler vs. Cement Grout for Brick Pavements

Sir—In an editorial comment on my letter published in your issue of Dec. 26, 1912, you state that the "Association of Paving Brick Manufacturers is emphatic in its preference for a grout filler for brick-block pavement and

requires the use of grout in its standard specifications." A leaflet recently published by the Western Association of Paving Brick Manufacturers has caused some question in my mind as to whether this preference is as emphatic as your comment would indicate. The leaflet describes a new form of brick-block pavement which will be placed on the market this coming year and which is especially adapted to bituminous filler. The block is to be wire cut and not repressed, 3x4x8½ in. in size, laid with a 4x8½-in. face up. This block has square horizontal edges, although the vertical edges are slightly rounded and lugs are formed by the die on one longitudinal face. After laying and rolling, the brick are to receive a coat of bituminous filler squeezed into all joints and enough left on the surface to form a coating about ⅜ in. thick, after being properly sanded. The rough wire-cut surface offers a good chance for bond between the filler and the brick. The blocks are to be made of the same quality of shale and the same degree of vitrifaction as the present brick block.

The advantages gained are decrease in cost of manufacture, a decrease in the number of brick and brick material per square yard of pavement, the elimination of expansion troubles and a smooth, noiseless, nonslippery pavement. It is, of course, possible to use a cement-grout filler with these brick but in that case, some of the above advantages would not obtain. In all fairness it must be said that both the bituminous and cement-grout filler have objections but those to the cement are inherent in the grout while the chief objection to pitch filler may be overcome, I believe, by changing the present form of block. In theory, cement grout has many good qualities, but in practical application to the paving on a busy street in a large city, where the weather and traffic conditions, the expansion, cuts for service pipes and conduits, street-railway traffic, etc., annul a great many of these advantages.

I believe the majority of municipal engineers and the brick manufacturers as well are not entirely satisfied with the cement-grouted brick pavement as it has been possible to lay it and it seems to me that this new form of brick with a bituminous filler has wonderful possibilities.

CLARK R. MANDIGO, Asst. City Engineer.

Kansas City, Mo., Jan. 10, 1913.

Internal Water-Pressure in Hollow Dams

Sir—In Mr. Bilderbeck's recent article on "Protection for Hollow Reinforced Concrete Dams" (Nov. 21, 1912, p. 948), some rather strange statements are made about the effect of holes in the upstream deck.

Let us investigate his section of a triangle 40 ft. wide, 20 ft. high, withstanding a head of 30 ft. (Fig. 1 herewith). As a rough approximation, assume the masonry to weigh 30,000 lb. per lin.ft. The horizontal thrust of the water is 25,000 lb., the weight of water above the dam is 25,000 lb., giving $W_1 = 35{,}000$ lb. and a resultant R_1 of 60,000 lb. at a slope of 1 in 2.2.

When a large hole is broken in the upstream deck (Fig. 2), the horizontal thrust remains at 25,000 lb., but the weight of water above the base becomes 50,000 lb., giving $W_2 = 56{,}000$ lb. and resultant $R_2 = 84{,}000$ lb. at a slope of 1 in 3.2. The hole is a decided improvement. It is assumed, of course, that the dam was designed with an eye to possible large holes and properly reinforced.

Now let us examine the effect of uplift. Despite the apparent perfection of the latest cut-off scheme, water pressure under the dam is not at all impossible. Perhaps the drains become plugged, perhaps an inclined porous layer leads underneath the trench up to the center of the base. Assume an uplift head of 15 ft. acting over the central 20 ft. and decreasing to zero at either end, a force of 28,000 lb. In Fig. 1, the water pressure becomes $W_3 = 25{,}000$ lb. and the resultant $R_3 = 37{,}000$ lb. at a slope of 1 in 1.1. In Fig. 2, the water pressure is $W_4 = 32{,}000$ lb., with a resultant $R_4 = 58{,}000$ lb. at a slope of 1 in 2.1.

Thus it appears that, far from being a source of danger, the large hole was really an act of Divine Providence to save the dam from sliding.

Now having discovered the value of an occasional hole, the next step is to remove the upstream deck altogether,

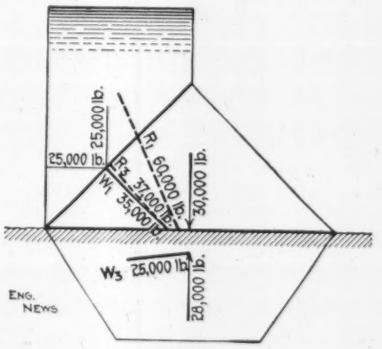


FIG. 1

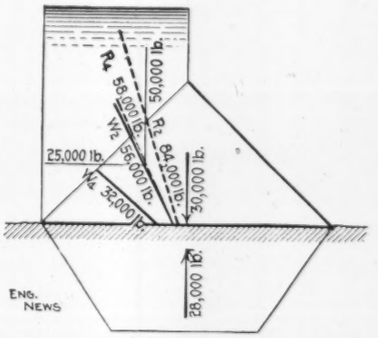


FIG. 2

or, in cold countries, all below the ice line. Such a dam would be stronger than one of the hollow empty type and its additional safety would cost nothing, as the saving in deck would pay for the steel required in the buttresses and base.

D. STAIRS,
Care of The Acadia Sugar Refining Co., Ltd.

Halifax, N. S., Nov. 29, 1912.

[Mr. Bilderbeck replies to these comments as follows]:

Sir—Referring to the above letter, there seems to be a disagreement due, I believe, to a misunderstanding.

The statement made in the writer's article of Nov. 21, 1912, relative to the effect of breaking a large hole in the upstream face of a dam is as follows:

> Now suppose the upstream slab breaks, so as to fill the enclosure with water, an upward hydrostatic pressure will exist on the downstream slab of 25,000 lb., and the sliding pressure will be the same as in normal conditions.

Mr. Stairs deducts this 25,000 lb. upward pressure from the total weight of the water on the base slab. The pressure on the base slab has nothing whatever to do with the failure of the downstream slab due to the pressure on it as this dam is ordinarily constructed. To prevent possible failure the downstream slab would have to be designed for the same loads as the opposite side, with additional means of clamping the slab to the buttresses. In practice this is not done, and if it were the cost would be in many cases prohibitive.

A large percent of the concrete dams of the above type have weep-holes in the bottom slab to lessen the possibility of upward pressure on the bottom of the slab. In dams of this type, water in the enclosure would reach the bottom of the base slab, equalize its own weight on the top of the slab, and cause the structure to overturn or float out of place.

In the article of Nov. 21 mention was made only of the dams as they are being built, and as is practicable to build them. It is granted without argument that a hollow structure could be built that would withstand all possible conditions with a large factor of safety. However, there are three conditions that would determine the efficiency of a design: utility, safety, and cost. Any one or two of the three must not be developed regardless of the others.

Referring to the infiltration chamber mentioned, attention is invited to the fact that when the material forming the foundation under a dam is so impervious that only small veins of water reach the bottom of the slab there will be no danger of a pressure being distributed over a distance of 20 ft. as assumed. If it spreads 20 ft. between the slab and its foundation under the pressure assumed, why not 5 or 6 more and reach a condition of no pressure?

The upstream slab of the dam could be omitted, in part at least, as suggested, but it is thought the difficulties of safe construction would more than offset the advantages. It would be as necesary to prevent the upward pressure on the bottom of the base slab as in any type of dam. It would be as advisable to prevent the impact being carried directly into the masonry as in the general type of dam. All the suggested improvements mentioned in the article of Nov. 21 would be needed in this type of dam as much as in any.

The writer wishes to thank Mr. Stairs for his opinion on hollow concrete dams, not, however, for the acrimony in his manner of stating the opinion, but in spite of it.

G. L. BILDERBECK, Ass't Engineer,
Conn. Rivers, Harbor, and Bridges Commission.
New London, Conn., Jan. 13, 1913.

NOTES AND QUERIES

Erratum—**Ore Docks**: In the description of the steel ore dock of the Duluth & Iron Range R.R., on page 15, of our issue of Jan. 2, the address of O. H. Dickerson was given as Detroit. This should have been Duluth, Minn., Mr. Dickerson being Principal Assistant Engineer of the Duluth & Iron Range R.R. In regard to the ore dock of the Great Northern Ry., described on page 11, of the same issue, it is suggested that this should be considered rather as a plain concrete structure, the amount of reinforcement being extremely small and intended mainly for the protection of the corners of the columns. This seems to be a correct idea, since the article states that in each of the massive concrete columns, 84x33-in. section, there were only four ⅞-in. steel rods, one at each corner. The floors and partitions of the pockets of this dock are of steel, while in the ore dock of the Lake Superior & Ishpeming R.R. (page 9 of the same issue) these parts are of reinforced concrete, formed integrally with the supporting columns.

Annual Convention of the American Wood Preservers Association

The ninth annual convention was held Jan. 21 to 23 at the Sherman Hotel, Chicago. The attendance was larger than usual, and the character of the proceedings indicated a growing recognition of the importance of the association and its work. At the morning meeting on Jan. 21, the President, E. A. Sterling (Philadelphia), read the annual presidential address, reviewing some of the activities and possibilities of the association. The report of the Secretary, E. J. Angier (Baltimore), showed a cash balance of $1124 and a membership of 177, both figures representing a marked advance over the previous year. It referred also to the present practice of the association in sending out bulletins containing notes of articles published in the technical and trade papers which relate to timber and timber preservation. An amusing but instructive address of welcome was delivered by Bolling A. Johnson (Editor of the *Lumber World Review*), who pointed out that lumber men in general are beginning to recognize the practical relation of wood-preservation to the lumber industry. He thought that the trade papers could help this by publishing more information in regard to wood preserving. Mr. Johnson also voiced a warning to the effect that many lumbermen regard the association as too scientific or technical to affect the commercial side of the question, and stated that the manager of one preservation plant said he did not intend to attend the meeting, as it would be composed only of "a lot of high-brows." The association should seek to correct such ideas, and the more publicity it gives to its work the better it will be for the association itself, for the wood-preserving industry, for timber conservation, and for the lumber trade in general.

The officers elected for 1913 are as follows: President, A. E. Larkin (Republic Creosoting Co.), Minneapolis, Minn.; Vice-President, J. H. Waterman (C., B. & Q. R.R.), Galesburg, Ill.; E. B. Fulks (American Creosoting Co.), Louisville, Ky., and Geo. E. Rex (A., T. & S. F. R.R.), Topeka, Kan.; Secretary and Treasurer, F. J. Angier, B. & O. R.R., Baltimore, Md. The next meeting will be held at New Orleans, La., in January, 1914.

Wood-block Paving

A paper on "Timber for Creosoted Block Paving," by H. G. Davis (Chicago), discussed the suitability and comparative merits of different woods available in the central states, and suggested that tamarack, hemlock and maple are quite as good as the long-leaf yellow pine, which is so generally assumed to be superior to any other. We shall publish an abstract of this paper in a later issue. A paper on "Yellow-Pine Block Pavement," by H. L. Collier (St. Louis), presented this as best meeting requirements as to sanitation, efficiency, economy and durability. He suggested, however, that special care should be taken in making the concrete base, and preferred a mortar bed (1:3) to a sand bed for the blocks. The mortar should be mixed and laid dry, struck off with a

template and then sprinkled just in advance of the pavers. A still better plan is to use a coating of hot pitch or asphalt mixed with 10% (by weight) of portland cement. At the curbs there should be expansion joints 1 in. or 1½ in. wide for 30- or 50-ft. streets. As to the timber, he considered that sap-wood and heart-wood when treated have equal wearing properties, and that specifying a certain percentage of heart-wood only serves to add to the cost. The methods of constructing the curbing and concrete base and laying the paving was described in a paper on "Laying Wood-Block Pavement," by H. S. Loud (New York). He pointed out that a sand bed gives a real cushion effect, but advocated a mortar bed on grades, especially on street-car tracks. In foreign practice, however, the concrete base is finished to a smooth surface and the blocks are laid directly upon it. As to the timber, he stated that long-leaf yellow pine and southern black gum have been standard for streets of heavy traffic; tamarack and Norway pine have been used in the West, and North Carolina pine is coming into favor in the East for streets of moderate traffic and with heavy grades. This last wears uniformly and permits crushed stone to be rolled into the surface, making it less slippery than long-leaf pine.

Zinc-chloride, Creosote Oil and Crude Oil

A paper on "Comparison of Zinc-Chloride and Creosote," by Howard F. Weiss, showed a decrease in the number of ties treated annually with zinc-chloride and an increase in those treated with creosote, for the five years 1907-1911. His conclusions were as follows: 1, both are effective and there is little choice as far as annual charges are concerned; 2, creosoted ties generally cost more than burnettised ties, the cost of treatment being two or three times as great; 3, creosoted ties average a longer life, and therefore require less frequent renewals and disturbance of the roadbed; 4, if the price of creosote advances it may result in stimulating the use of the zinc-chloride process. Mr. Goltra, in a lengthy discussion, stated that the real reason for the increase of creosoting has been the exploitation of the empty-cell process for which so much has been claimed, and which is being used extensively. Of the 16,510,700 ties creosoted in 1911, he estimated that 14,000,000 were treated by this empty-cell process, the ultimate value of which is questioned. Mr. Waterman stated that 550 burnettised red-oak ties laid in 1900, gave 12 years service, and on inspection in 1912 only 18 had to be removed on account of decay. Of burnettised pine ties on 15 miles of railway in Colorado, 97% gave 12 years service. These had tie-plates only on curves, while all the oak ties had tie-plates. Both lines carry heavy traffic and very heavy engines. He considered that 50% of the ties would give 20 years service. Mr. Buehler thought that creosoting plants in this country do work as good as that of any foreign plants, and that our creosoted ties would show as long a life if equally well protected and watched. Mr. Goltra had argued in favor of crude oil as a preservative, and referred to the long life of oil-soaked timbers in the oil fields. It was pointed out, however, that to lay ties in track is a very different matter. Mr. Buehler mentioned a case where ties in a siding were kept soaked with oil dripping from cars. But as soon as this siding ceased to be used for tank cars, the ties began to show signs of decay.

Two papers related specifically to coal-tar creosote. One of these, by L. B. Shipley, was a review of some laboratory tests on: 1, the distillation of oils; 2, the comparative volatility of oils, and 3, the extraction of oils from treated wood. Other tests to be conducted include: 4, the volatilization of oil from treated wood; 5, the leaching of oil from treated wood, and 6, the antiseptic values of different oils. The second paper, by E. A. Sterling, dealt with the production and supply of creosote oil, and showed that only a small proportion of the necessary supply is of home production, for the reason that creosote is not made to meet the demand, but is a resultant from distillation carried on to recover by-products. Of 78,000,000 gal. consumed in this country in 1912, 75% was imported. In view of the commercial conditions, other preservatives should receive careful consideration; these might include, crude-oil, water-gas creosote, and refined tar in combination with creosote. It would be profitable also to study the methods of treatment, and eliminate a heavy impregnation where (on account of mechanical wear or other causes) a lighter treatment would suffice. In a paper on "The Preliminary Treatment of Timber to Insure Satisfactory Impregnation with Creosote," David Allerton suggested a difficulty in raising the temperature to the required height in the interior of large sticks.

Miscellaneous

In a paper on "The Requirements of Successful Timber Treatment," Herman von Schrenk said the requirements were: 1, sound timber; 2, proper seasoning; 3, good preservative; 4, proper injection; 5, proper handling of the treated material. He protested against the tendency to conduct the treatment in accordance with any demands which may be made by the customer, as this results in dissatisfaction which reacts on the entire industry. Two papers dealt with the treatment of Douglas fir, and two more with treatment of wood for floors and freight cars. For freight-car floors, where the effect of mechanical wear is greater than that of decay, a zinc-chloride or light creosote treatment was considered more advisable than heavy creosoting. The use of machines for boring and adzing ties was discussed in a paper by J. A. Lounsbury (Rockford, Ill.), referring to machines of a class described in Engineering News of Oct. 19, 1911. The piecework system of handling ties and timbers at treating plants was advocated by W. W. Eldridge (C., B. & Q. R.R.), and A. M. Smith (Argenta, Ark.) stated that he had found no machines so satisfactory as hand labor. In a paper on "Sap in Relation to the Properties of Wood," S. J. Record explained that there is more sap in growing wood in winter than in summer, contrary to common opinion. In the discussion on this paper, Mr. Weiss referred to a number of prejudices against certain woods which investigation has proved to be unfounded: 1, wood cut in summer does not contain more water than winter-cut wood, but the reason it is more liable to decay is that the wood pores or cells are more open, and the conditions for fungus growth are more favorable; 2, wood is not weakened by sap stains or by the soda-dip to prevent these stains; 3, wood turpentine (distilled) is not inferior to gum-turpentine; 4, bleeding for turpentine does not weaken the timber; 5, red-hickory is not a useless timber, and as a result of investigation it has been used extensively for pick-handles.

Recent Development of Gas Power in Europe*

By H. J. Freyn†

SYNOPSIS—A notable summary of European progress in gas and oil engines was a feature of the recent annual meeting of the American Society of Mechanical Engineers. The retiring Chairman of the Gas Power Section of the Society, Mr. H. J. Freyn, Consulting Engineer of the Allis-Chalmers Co., spent several months abroad last year studying European practice in gas- and oil-engine design. His address summarized the results of his studies, and makes clear the extent to which gas and oil engines have supplanted the steam engine on the Continent of Europe.

The development of the internal-combustion engine in Europe during the last year has been very marked and great strides were made, especially by the Diesel engine. The unparalleled progress of this prime mover, due primarily to the expiration of the basic Diesel patents, created a wave of enthusiasm, the crest of which swept Europe only a short time ago. To the careful observer, however, signs of an ebbing of this wave are apparent and more sober, more healthy views are gaining ground.

OIL ENGINES

LARGE DIESEL ENGINES—Without desiring to detract from the importance of the Diesel engine, investigation has proved to me that my warning against over-enthusiasm sounded about a year ago on a similar occasion was fully warranted.

In particular, I was disappointed to find that the achievements with large Diesel engines, above 1000 hp., do not altogether coincide with the optimistic reports which have appeared in the technical press of the world during the past year or two. It is not certain that the large Diesel engine will be an undisputed commercial success abroad, since the price of natural fuel oils is steadily increasing, thus largely limiting such engines to the use of tar oil.

The horizontal double-acting four-cycle M. A. N. Diesel engine in twin tandem arrangement of 1600-2000 b.hp., which I had the privilege of examining at Halle, a. S., is a splendid piece of machinery and operates apparently very satisfactorily on tar oil with a small addition of ignition oil. It is claimed that such an engine can be sold in Germany for from $30 to $32.50 per horsepower, against $35 per horsepower for a steam plant. It would be expected, however, that the repair and maintenance cost would be much higher than for a steam plant and even higher than for present gas engines, on account of the high pressures and temperatures which are essential with the Diesel working principle and because of carbonization at partial loads which can be prevented only by scrupulous cleanliness. In countries where the price of coal is high, this engine type may have some importance, and a number of such engines of even larger unit capacity than mentioned have been sold in France and Russia, where fuel conditions are favorable for this type.

SMALL AND MEDIUM SIZED DIESEL ENGINES—The Diesel engine in sizes of from 40 or 50 hp. in single-cylinder units up to about 600 hp. in four-cylinder units plays a vastly more important part abroad. It has unquestionably come to stay and has reached a high degree of perfection which places it in line with the corresponding steam- or gas-engine plant as far as reliability and cost of operation are concerned, and far ahead of its competitors from the standpoint of fuel economy. It is amazing to note how many manufacturers of gas and steam engines abroad have taken up the manufacture of Diesel engines, because they found that the sale of suction gas-producer plants and smaller steam engines had fallen off alarmingly during the last few years.

The reason is plain. The single-acting, four-cycle, single or multi-cylinder Diesel engine, but particularly the former, is comparatively simple in construction and operation, especially when its unequal efficiency is considered, for it is certain that, generally speaking, complication of any mechanical contrivance increases with increasing efficiency. This engine is always ready to be put in service at a moment's notice and has no standby losses; it does not require upkeep and attendance of boilers or gas producers and its cost compared with that of steam or gas plant is reasonable. It can be installed in the basements of buildings below occupied dwellings, whereas in Europe boilers are not permitted in such places. One of the greatest advantages which cannot easily be expressed in figures, but is of vast importance to the consumer, is the fact that the actual fuel consumption of Diesel engines, taken over long periods of operation, does not materially exceed the guaranteed figures, whereas in gas-producer and steam plants this excess is quite considerable. A few months ago a German technical periodical contained an article showing that the actual fuel consumption during a period of one whole year was for certain Diesel engine plants only 14 per cent. higher than the guaranteed figures given by the manufacturer, whereas it averaged 120 per cent. more in high-class steam locomobile plants. In this comparison 27 installations containing units of 50 to 80 hp. were investigated, 12 of which were locomobile plants, whereas 15 contained Diesel engines. In a Diesel plant the human element, the skill of the operator must have much less influence upon the fuel economy than in a steam or producer-gas plant where everything depends upon the efficiency and intelligence of fireman and producer attendant.

While the Diesel engine is originally a vertical engine, the last two or three years have witnessed a remarkable development of the horizontal Diesel engine. With few exceptions the manufacturers of vertical Diesel engines have branched out to build horizontal engines as well for purely commercial reasons. Experience shows that the fuel consumption is only very little, if any, higher than that of vertical engines, but the horizontal type is decidedly preferred by the customer, not only on account of its lower cost, but particularly owing to its greater simplicity and better accessibility. Especially the horizontal Diesel engine with Lietzenmayer's open fuel injection nozzle offers these advantages in their full measure. The open nozzle is simpler, can be easier taken care of by unskilled attendants, gives better results when burning heavy oils and is less sensitive in its action than the so called closed injection nozzle of the original Diesel engine. The horizontal open-nozzle oil engine has the additional advantage that certain essential accessories, such as the starting gear and the fuel pump, can be designed much simpler than for the other type. Many engines of the former type are in very successful service, using all kinds of fuels and installed for various purposes, for instance, for power transmission, for operating flour mills, for lighting factories, sanitariums, office buildings, department stores and for electricity works.

The only difficulty of which some users of small and medium Diesel engines sometimes still complain is caused by the discharge valves of the air compressors for fuel injection, and although these difficulties have been greatly reduced, numerous efforts are being made to materialize the dream of the "compressorless" Diesel engine. I had the privilege of seeing a 12-hp. experimental engine of this type in operation, which seemed to give good results, since an oil consumption of only 0.48 to 0.5 lb. per b.hp.-hour is claimed, but it is not certain that this principle, which has been tried many times before, would be applicable for larger engines.

MARINE ENGINES OF THE DIESEL TYPE—In view of the great importance of the Diesel engine for ship propulsion, there is little wonder that great effort is directed by many manufacturers to the design and construction of an engine which, while having nearly the same excellent fuel economy as the stationary engine, will also meet the severe requirements of simplicity, reliability and reduced first cost. That the last condition is not yet fulfilled is shown by the fact that, according to authentic information, the cost of an 800-hp., four-cylinder, two-cycle marine engine recently built was 50% higher than anticipated and 150% higher than for a corresponding steam-engine equipment. I was nowhere able to find the 10,000- and 15,000-hp. Diesel-engine ships of which I had read, and even enthusiasts do not believe that our modern leviathans will be propelled by Diesel engines.

The largest single Diesel-engine unit propelling any ship afloat develops not over 2000 hp., and there still remain many obstacles to be overcome before the single-acting multicylinder, four- or two-cycle Diesel engine on board ship is supplanted by the double-acting engine. Vertical engines

*Presidential address at the Annual Meeting of the Gas Power Section of the American Society of Mechanical Engineers.

†Consulting Engineer, Allis-Chalmers Co., West Allis, Wis.

of the latter type are still in the experimental stage, and their future does not appear very promising on account of the serious mechanical complications of scavenging pumps and multiplicity of scavenging valves in each cylinder head.

The lack of simplicity in these designs has prompted experiments with the so called "valveless" two-cycle type, which presumably will become the large marine Diesel engine of the future. One valveless two-cycle experimental engine of 260 hp. is claimed to have shown an economy as good as that of a regular two-cycle engine with scavenging valves. The mean effective pressure obtained reached 125 lb. per sq.in., which is truly remarkable in view of the extremely simple scavenging method employed.

THE JUNKERS OIL ENGINE—Among the valveless, two-cycle engines, the Junkers oil engine has attracted a great deal of attention. It has reciprocal pistons, a three-throw crankshaft, and differs essentially from the regular type. An advantage is the excellence of the form of combustion space which, from a thermodynamic point of view, at least, gives it the distinction of being the best oil engine. Practical experience alone will tell whether its unusual design and certain mechanical disadvantages will be offset by this advantageous feature. One of the foremost authorities in Europe very graphically characterized the Junkers engine as an oil engine built around a given perfect combustion chamber in contradistinction to all other Diesel engines where it is attempted to provide a satisfactory combustion space in an existing engine. Only a few smaller engines, mostly for marine propulsion and of the twin- or three-cylinder vertical type have been built abroad. The tandem arrangement of cylinders which results in the same number of crank efforts realized in ordinary single-cylinder, double-acting, two-cycle engines has so far been applied only on two 800-hp. three-cylinder vertical engines to be fitted in a vessel of one of the largest steamship companies. Aside of two experimental engines in Prof. Junkers' famous laboratory, no horizontal engines of this type have been built and opinions abroad are much divided concerning the future of the stationary, horizontal, tandem Junkers engine.

CONDITIONS AFFECTING THE DEVELOPMENT OF THE DIESEL ENGINE—If conditions in Europe are not altogether favorable for the development of the large Diesel engine, they are much less so in this country. The misapprehension frequently prevails that the Diesel engine must have a wonderful field of usefulness in countries where crude oil is produced in very large quantities, but such is not the case. The price of oil fuel in any locality must be considered in connection with the prevailing coal price to determine whether a Diesel engine installation is economically efficient or wasteful. Cheap oil fuel will favor the Diesel engine only where coal is very expensive, as on the Pacific Coast, whereas high oil and low coal prices will exclude it from any part of the country where such conditions exist. Considering that the total cost of producing power is made up of a number of items, as interest on the money invested and depreciation of the plant, cost of fuel, cost of attendance, maintenance and repairs, cost of supplies, etc., it is evident that in Europe where fuel prices are from two or three times higher, while labor is only one-half to one-third of what they are in our country, the item of fuel cost constitutes a very high percentage of the total cost of power, particularly since the other items, such as interest and depreciation, attendance and repairs are actually much lower and thus form a still smaller percentage of the total cost.

With us conditions are practically reversed: Our fuel cost is not only lower and our labor cost much higher than in Europe, but, morever, the quality of our mechanical labor is not as excellent, and thus the fuel cost plays a much less important role in the total cost of power than the items into which labor largely enters, whereas the lower standard of manufacture, and especially of maintenance, favors the use of simple although less economical machinery.

To what importance the use of coal-tar oil has grown on the Continent can be judged from the fact that France has to rely on this Diesel-engine fuel almost exclusively on account of the very high import duty on natural oils. In Germany a number of collieries have combined to form a company for the utilization of tar which operates a large factory at Meiderich, where, at present, over 300,000 tons of tar a year is distilled, producing over 80,000 tons of tar oil. This is contracted for in larger quantities at a price of approximately $12.50 per ton (5c. per gallon). With the tremendous increase in demand, it is expected that before long this one factory alone will have a capacity for handling one million tons of tar per year, producing 300,000 tons of tar oil.

It is estimated that the total world production of coal-tar oil is even now in the neighborhood of 1,000,000 tons per annum, and since the recognition that coal is too valuable a fuel to be wasted in our present-day furnaces is spreading more and more, the number of byproduct coke-oven and by-product gas-producer plants will steadily increase, especially in our country, so that the total production of tar oil is certain soon to double and treble, adding to our supply of natural liquid fuels an artificial product which will by legitimate competition check the advance in the price of the former.

The heat value of tar oil is over 17,000 B.t.u. per lb., and its consumption in the Diesel engine is, therefore, not very much higher than that of natural oil, varying now from 0.49 to 0.46 lb. per b.hp.-hour, according to the size of the engine.

The operation of medium size Diesel engines on tar oil, especially of those above 50 hp. per cylinder and with open fuel-injection nozzle is satisfactory. For smaller engines the addition of a so called ignition oil is necessary, which somewhat complicates these engines.

GAS TURBINES

Renewed activity is noticeable abroad in the matter of designing an adequate gas turbine. The foremost authorities are convinced that the gas turbine will soon come to stay and, in view of the universal tendency toward high-speed rotative machinery, the statement would seem warranted that when the gas and oil turbine does come it will revolutionize power production in the large steel centers and wherever natural fuel oils abound in this country. A large experimental gas turbine in Germany is operating splendidly, mechanically speaking, although the problem of satisfactory thermal efficiency still remains to be solved.

INDUSTRIAL WASTE GASES

The use of the so called "industrial waste gases" has progressed considerably. The four most prominent manufacturers in Germany alone are now building large gas engines for blast furnace and steel works at the rate of 120 per year, and a number of twin tandem engines of 5000 b.hp. operating very satisfactorily on rich coke-oven gas can now be seen in German coking plants.

The splendid results obtained with gas blowing engines in Germany have prevented the turbo-blower from getting a firm foothold in that country, although its use in France, England and Russia is steadily increasing. Blast-furnace gas engines for blowing and electric-power purposes and even for operating rolling mills are today the standard equipment for old and new plants, even where the coal price is fully as low in our Pittsburgh district. Within the last two years the use of coke-oven gas for producing electric power by gas engines has greatly increased, and after overcoming the many earlier difficulties the coke-oven gas engine is today just as safe and reliable as the blast-furnace gas engine. These difficulties arose principally from overrating the engines, and from sulphur in the coke-oven gas. Since the reasons for the trouble were recognized, the causes, or their consequences, are now avoided, so that in a number of plants sulphur of considerably over one grain per cubic foot of gas is very successfully handled in coke-oven gas engines if the proper very simple precautions are taken.

DETAILS OF CONSTRUCTION

In regard to the detail construction of the modern German gas engine a few remarks may be of interest. The most prominent gas-engine builders are now governing their engines on a simple combination quantity-quality regulation principle. The valve gear has been much simplified by all manufacturers, and gas-engine prices are, generally speaking, lower than they ever were before. The gas cylinders, after a few unsatisfactory attempts to use cast steel, are invariably made of cast iron, and with the exception of a few types are cast in one piece with integral water jacket. They are often provided with hard cast-iron liners. The cracking of gas cylinders is now much reduced by proper design, selected material and better pouring methods. Experience has taught that the life of a gas cylinder can be materially increased if the water jackets are thoroughly cleaned from all scale and muddy deposit at regular intervals of from four to eight weeks, depending upon the character of the cooling water used. It was found by experiment that the average temperature of the cylinder wall increases at an amazing rate with even a very thin layer of scale forming in the water jacket, and in certain plants with hard cooling water, acid and wire brushes are resorted to from time to time to take the accumulated scale off the cylinder walls.

Gas cylinders on electric engines crack more frequently than on blowing engines because the former carry much higher loads than the latter, and because electric engines are usually shut down oftener. It was found that frequent shutting down and starting of gas engines shortened the life of

the cylinders materially if the engines were allowed to cool off too much during shutdowns.

The average life of a gas-engine cylinder in the large steel plants in Germany is pretty generally reckoned to be from five to six years. This is accepted as a matter of course, and the expense incurred by replacement is simply distributed over this number of years in the cost figures.

The cost of producing electric power in German blast furnace and steel plants is about $2.70 per thousand kilowatt hours, comprising $1.25 value of the raw blast-furnace gas and including cost of gas cleaning, cost of labor, repairs, and supplies of all kinds, but without interest and depreciation on the money invested. This figure applies on an annual output of about 100,000,000 kw.-hours, and a use factor of approximately 60%.

The gas-engine pistons are generally ribless cast-iron castings, although for large engines cast steel is used. One concern has recently introduced for blast-furnace gas engines solid, noncooled, forged-steel pistons of one piece.

The piston rods are now usually made of openhearth steel of about 100,000 lb. tensile strength, uncambered, and their diameter is approximately 26% of the diameter of the gas cylinders. A variety of piston-rod coupling designs is used, but the threaded connection enjoys the best reputation. It is noteworthy that crossheads are made of forged nickel steel.

No uniformity of design can be claimed for piston-rod packings, but they invariably consist of single or double sectional cast-iron packing rings pressed against the rod by garter springs and separated by solid one-piece rings forming from 12 to 14 chambers. It is universally claimed that the clearances of the ring sections must be reduced to the possible minimum. So called fire rings are sometimes used, but several builders object to such solid rings.

The exhaust valves are made of forged steel or of "Durana" metal, and are now almost exclusively of the noncooled mushroom type. Some builders, however, still prefer water-cooled exhaust valves for coke-oven gas engines.

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A Study of Malaria in Alabama is reported on by R. H. von Ezdorf, surgeon, U. S. Public Health Service, in Public Health Reports for Dec. 27, 1912. At the end of the report, which covers a number of pages, the following conclusions are given:

All forms of malarial fevers prevail in the state of Alabama.

Morbidity reports indicate that in September, 1912, about 1 person for every 50 population suffered an attack of malarial fever, and during October, 1 person in 67 had an attack.

The types of infection, in the order of prevalence, are: Tertian, estivo-autumnal and quartan.

The chronic type of malarial infection is proportionately greater in the colored race than in the white.

The Flood of January 9, 1913, at Pittsburgh, Penn.

By Kenneth C. Grant*

On Jan. 9, the fourth greatest flood in 48 years visited Pittsburgh, reaching a gage height of 31.3 ft., or 9.3 ft. above the "danger line" of 22 ft. The direct losses due to this flood in the city of Pittsburgh alone amount to considerably over $1,000,000. Heavy losses were also sustained by various communities on the rivers above and below the city.

Since Mar. 18, 1865, when a stage of 31.4 ft. was recorded, the rivers at Pittsburgh have been higher than the recent flood only three times, namely: Feb. 6, 1884, 33.3 ft.; Mar. 1, 1902, 32.4 ft.; Mar. 15, 1907, 35.5 ft. On Feb. 18, 1891, the same stage, 31.3 ft., was reached. It is the first time that a January flood has ever crossed the 30-ft. stage at Pittsburgh, although in January, 1862 and 1904, the rivers rose to 30 ft.

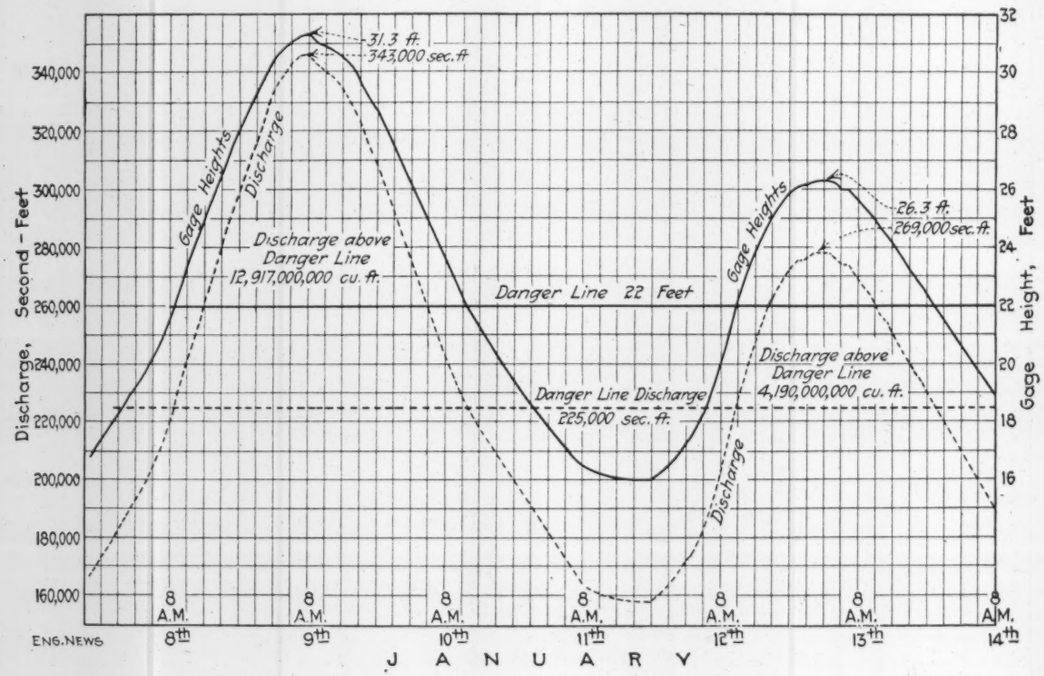


Fig. 1. Gage Height and Volume of Discharge of the Ohio River at Pittsburgh during the Flood of Jan. 8 to Jan. 14, 1913

The recent flood, therefore, ranks with the great floods of Pittsburgh and, as such, deserves description. It is also of particular interest because of the exhaustive studies and report which have recently been completed by the Flood Commission of Pittsburgh, and the attention that has thereby been drawn to the flood problem of this region.

The flood was caused by a warm rain of no very great intensity at any particular point, but fairly uniformly distributed over the entire drainage area above Pittsburgh, the total precipitation for Jan. 6 to 9, inclusive, averaging about 2 in., and nowhere falling below 1 in. The maximum rainfall, so far as present records show, occurred at Rowlesburg, W. Va., on the Cheat River Basin, and amounted to 2.5 in. The principal rainfall occurred during the 24 hours preceding 8 a.m. on Jan. 8.

The drainage area to the north and northeast above

*Consulting Engineer, Arrott Bldg., Pittsburgh, Penn.

Pittsburgh had a depth of snow on the ground averaging from about 1 in. at Pittsburgh to 5 in. in the northern Allegheny Basin. With the exception of scattered drifts in the mountainous section to the east, there was practically no snow on the Monongahela Basin. The high temperature that prevailed preceding the flood melted all this snow, and it ran off with the first part of the rainstorm.

The rainfall recorded on the morning of Jan. 7 at the stations reporting directly to the local forecaster of the U. S. Weather Bureau at Pittsburgh, and the weather indications of continued precipitation, caused a prediction of a stage of over 20 ft. by the morning of the 8th. This prediction was proved correct by the stage at Pittsburgh crossing the 20-ft. mark about 4:30 a.m. on the 8th. The rivers continued to rise rapidly, averaging about 6 in. per hour. The danger line of 22 ft. was crossed shortly before 9 a.m.

The continuance of the rain through the 24 hours preceding 8 a.m. on the 8th and the rainfall and river stages reported from the various stations at that time formed the basis of an estimate by the local forecaster of the Weather Bureau that there would be a stage of 31.5 ft. at Pittsburgh on the morning of the 9th. As a precaution, this estimate was increased to 32 ft., and warnings were sent out to the flooded districts and the river interests to prepare for a flood of that height. The rivers continued steadily rising until 7 a.m. on the 9th, when the maximum of 31.3 ft. was reached. The flood continued at this stage for about an hour and then began to fall gradually, at first only about 0.1 ft. per hour. At 4 p.m. on the 9th it had receded to 30 ft., but it did not fall below the 22-ft. stage until 12 noon on the 10th, having been above this stage for 51 hours, and above the 30-ft. stage for about 16 hours.

By 8 a.m. on the 11th the stage had fallen to 16.5 ft., from which point it gradually receded to 16 ft. during that day. At about 7:30 p.m., however, the rivers began to rise again, and at 10:30 a.m. on the 12th, or 47 hours after the water had fallen below the danger line, they had again risen above the 22-ft. stage. This second rise continued until midnight of the 12th, when the crest of 26.3 ft. was reached, 88 hours after the crest of the first flood. The water continued at this level for about three hours and then gradually receded, the 22-ft. stage not being reached until about 9:30 p.m. on the 13th, so that this second flood was above the danger line for 35 hours.

The second flood was caused by a rain which fell during the 48 hours preceding 8 a.m. on the 12th. There was no snow on the ground, but a high rate of run-off resulted from its saturated condition. The rainfall was heaviest on the upper Monongahela Basin. The maximum, according to records thus far available, occurred at Fairmont, W. Va., 127 miles south of Pittsburgh, where 2.47 in. was recorded. The greater part of the Monongahela Basin in West Virginia received over 2 in. The rainfall gradually decreased in amount northward, although a considerable portion of the middle Allegheny Basin received over 1½ in., the maximum recorded on this basin being 1.78 in., at Parker, 85 miles above Pittsburgh. The Allegheny Basin from Warren northward received something under 1 in.

The discharge of the combined Allegheny and Monongahela at a 22-ft. stage at Pittsburgh is about 225,000 sec.-ft. The discharge at the crest of the first flood reached about 346,000 sec.-ft. The total volume of this first flood wave above the 22-ft. stage was about 12,917,000,000 cu.ft. The discharge at the crest of the second flood was about 278,000 sec.-ft., and the total volume of this flood wave above the danger line was about 4,190,000,000 cu.ft. The total volume of the two flood waves above the danger line therefore amounted to about 17,107,000,000 cu.ft.

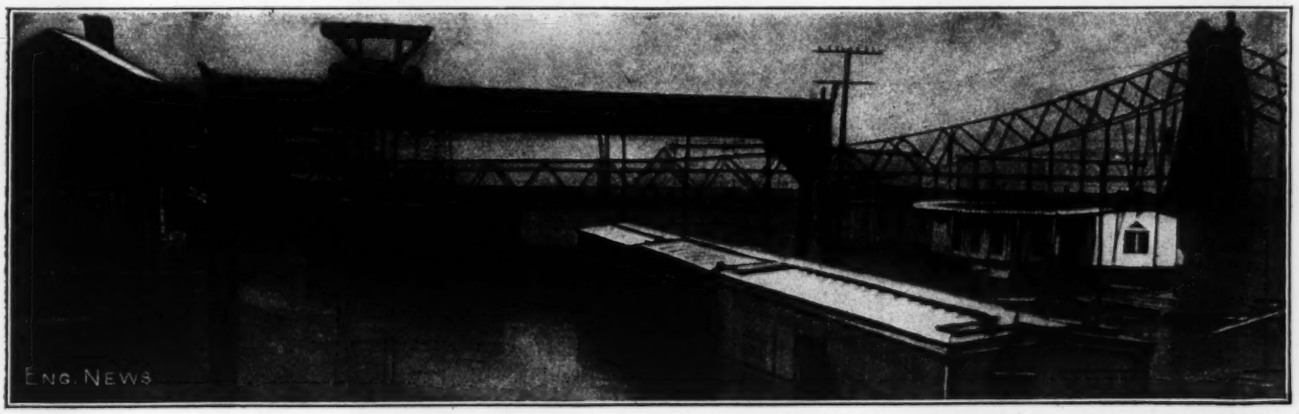


FIG. 2. RIGHT BANK OF ALLEGHENY RIVER LOOKING UPSTREAM, JAN. 9

The first and higher crest was caused by a fairly high stage in all the tributaries, due to the uniform distribution of the rainfall. The Allegheny River was a more important contributor to this crest than the Monongahela, largely on account of the high stage reached by the Clarion, which came within 0.6 ft. of record height, and delivered its flood waters at Pittsburgh just about at peak time. The Allegheny at Kittanning, 46 miles above Pittsburgh, and 40 miles below the mouth of the Clarion, rose to 25.3 ft., or to within 4 ft. of record stage. At Freeport, 30 miles above Pittsburgh, it was within 4.3 ft. of record stage, although the Kiskiminetas River, which enters just above this point, was 10.6 ft. below record stage at Avonmore. Compared with many of its past performances, the Kiskiminetas was of relatively small importance in causing this flood, the main offenders on the Allegheny being the tributaries entering from the east along its middle course, particularly the Clarion.

On the Monongahela Basin, the Youghiogheny River, usually a leading factor in Pittsburgh floods, rose to only 16.7 ft. at West Newton, or 11.5 ft. below record stage. The Monongahela at Lock No. 4, 41 miles above Pitts-

burgh, rose to 30.4 ft., or 11.6 ft. below its maximum, at 10 p.m. on the 8th, but this crest did not reach Pittsburgh until several hours after the flood peak had begun to subside. The West Fork at Enterprise was 17.4 ft. below record stage, the Tygart Valley River at Fetterman, 14 ft., and the Cheat River at Rowlesburg, 13.5 ft. Taken as a whole, therefore, the Monongahela was a less important factor than the Allegheny in causing the first crest of this flood.

The second and lower crest, however, was caused mainly by the Monongahela River, which, on the evening of January 12, reached about the same stage at Lock No. 4 as on the 8th, while the Allegheny at Freeport only came within about 6 ft. of its earlier crest. The West Fork River, at Enterprise, on the morning of the 12th, reached a stage about 2 ft. higher than in the first flood, and was the main factor in producing this second high stage at Lock No. 4, as none of the other main tributaries above this point had so high a crest as in the preceding flood. The Youghiogheny, at West Newton, was 3.4 ft. lower than during the first rise. All the gages on considerably under 1 in., and this scattered through the month in ineffectual showers. The temperature, moreover, was unusually high for that time of year, and the heavy blanket of snow melted off gradually without causing flood stages.

Damage

At the crest of the first flood, nearly 700 acres of low land within the city limits were submerged to a maximum depth of 11 ft. Over eight miles of main railroad tracks were covered to a maximum depth of 11 ft., about four miles of street-car tracks to maximum depth of 7 ft., and about 15 miles of streets and alleys to a maximum depth of 9 ft. Federal St., the principal business street on the North Side, which has recently been raised, was not flooded. If the street had been at its old grade, there would have been about 2½ ft. of water on it at the crest of the flood. On the Pittsburgh side of the Allegheny, this street was covered to a depth of nearly 2 ft. in the lower section between Penn Ave. and Duquesne Way. Street-car traffic was blocked and passengers had to be

Fig. 3. A North Side Street in Pittsburgh on Jan. 9

the Allegheny Basin recorded a lower stage than in the first rise, particularly in the northern section, where the rainfall was lightest.

The occurrence of these two floods in January, and with so short an interval between, is another significant warning of the menace of possible floods in the future that will far exceed all past records as to height and damage. If the precipitation causing the first crest had been in the form of snow, and had thus remained on the ground until the arrival of the rainfall causing the second crest, these two floods would have been combined, and much higher stages would have resulted at all points.

A providential deliverance from such a catastrophe occurred in 1910. The winter of 1909-1910 had been one of unusual severity, with a number of extraordinary snowstorms, a total of nearly 10 ft. having been recorded at some parts of the basins. An unprecedentedly large amount of this snow still lay on the ground at the end of February. If one of the usual heavy warm rains of March had then occurred, Pittsburgh would unquestionably have had a flood approaching the 40-ft. stage, 4.5 ft. above the record flood of 1907. Fortunately, however, March, 1910, had an unprecedentedly light rainfall, the average over the drainage area above Pittsburgh being transferred with wagons and motor trucks. All business was suspended on the north side of this street. The higher sidewalk on the south side enabled pedestrian traffic to continue, although it was seriously delayed by numerous blockades.

Street-car traffic throughout the city and outlying towns was seriously interrupted. In some cases re-routing was possible; in others, all operations were discontinued until the water subsided. All passenger trains on the Bessemer & Lake Erie, Pittsburgh & Western, and Buffalo, Rochester & Pittsburgh railroads were obliged to use the Water St. station of the Baltimore & Ohio, the tracks and station in the North Side being flooded on the 8th. The Pittsburgh & Lake Erie tracks on the South Side were covered in places to a depth of 6 ft., many passenger and freight cars on the sidings being half submerged. As a result of this tying-up of traffic, thousands were unable to reach their work on time on the 9th, and some not at all. In a large portion of the North Side the only method of travel was in boats, the water being 8 ft. deep in many of the streets. A number of motor-boat ferries were in operation, one route extending for about a mile.

All river traffic was tied up by the high water. Ship-

ments of coal by river were suspended on the 7th and not resumed until the 15th. A special trip of the new steamer "City of Parkersburg," to inaugurate a better passenger and packet freight service on the Ohio, had to be postponed from the 6th to the 16th.

The cellars of all buildings in the lower portions of the city were flooded. The timely warning sent out by the Weather Bureau allowed suitable preparations to be made and much damage was thus avoided. Flood barriers were erected at all openings, pumps put in operation, and merchandise stored in cellars and basements removed to the sidewalks or to upper stories. The residents in these lower sections were put to great suffering and inconvenience. Furniture and household goods had to be moved to upper stories, and the ground floors and basements were uninhabitable for several days. Food and fuel supplies were cut off, and these had to be furnished by the police department and local charity organizations, who did most effective work with a small fleet of boats.

The majority of industrial plants along the river

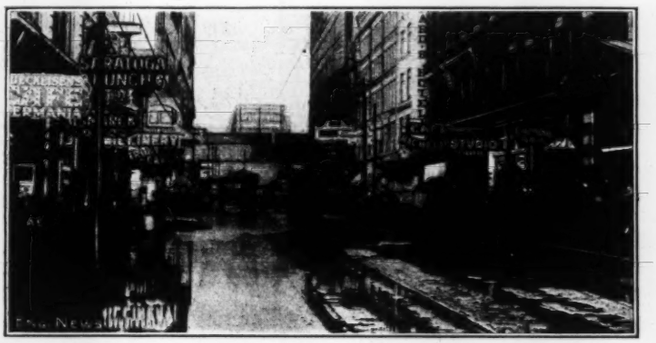


FIG. 4. A VIEW IN FEDERAL ST., NORTH OF PENN. AVE., JAN. 9

banks had to shut down, and many thousand men were thrown out of work for periods of from several days to over a week. One plant employing 3000 men had to suspend operations and a number of those shut down employ more than 2000. The loss to these wage-earners was very considerable and will be severely felt.

The new Union bridge, under construction across the Allegheny, near the mouth, narrowly escaped destruction. The north span was nearly completed, and by working night and day under very adverse weather conditions, the truss was connected up at midnight of the 8th, and the huge traveler moved to a point of safety over the channel pier. The wisdom of this precaution was shown when the entire falsework under the span was carried away during the flood. At the new bridge of the Pittsburgh & Shawmut R.R., under construction across the Allegheny at Mahoning, 58 miles above Pittsburgh, the falsework was carried away by the flood on the morning of the 8th. The truss fell into the river, causing a loss of about $30,000 and a delay of several months in the completion of the work.

The damage along the rivers above Pittsburgh was considerable. Manufacturing plants were shut down, residences and clubhouses flooded, and street-car and railroad traffic interrupted. Streets in some outlying towns were under 10 ft. of water. Many residents were marooned in the second stories of their homes. Business was at a standstill, and there was much suffering from scanty supplies of food and fuel. The aggregate loss was very considerable and it will be several weeks before all traces of the flood are removed.

The flood of Feb. 16, 1908, which reached a gage height of 30.7 ft., was above the danger mark for about 52 hours, or approximately the same length of time as the first crest of the recent flood, which, however, was 0.6 ft. higher. A careful canvass of the flooded districts immediately after this 1908 flood led to an estimate of about $840,000 direct loss within the city limits. Newspaper reports place the damage in the recent flood at over $1,000,000, and this is conservative, as the second flood of 26.3 ft. again placed the low districts under water and prolonged the time that some of the industrial plants were out of commission.

THE FLOOD ALONG THE OHIO RIVER

The flood did great destruction in its passage down the Ohio. All industrial plants along the lower lands bordering the river were inundated and many thousands of men temporarily thrown out of work. Railroad and trolley lines were blocked and traffic seriously interrupted. Many men were thrown out of work at the mines owing to the impossibility of obtaining cars.

The flood crest arrived at Wheeling, W. Va., 90 miles below Pittsburgh, at midnight on the 9th, when a stage of 44.6 ft., or 8.5 ft. below the record stage, was reached. This crest was 8.6 ft. above the danger line and drove over 600 families from their homes or to the second stories. Thousands of men are employed at the various plants along the river front, and at the mines on the Ohio side. The majority of these were thrown out of work for several days. Street-car and railroad traffic was at a standstill.

At Cincinnati, 468 miles below Pittsburgh, the danger line of 50 ft. was crossed on the night of Jan. 10, and during the 11th the rising waters began to flood the houses and buildings in the lower sections and to block traffic. Over 3000 families were driven from their homes, and school houses and churches were thrown open and filled with refugees. Rowboats and launches plied the streets, carrying the flood victims to places of safety and bringing food and fuel to the sufferers. The city appropriated $20,000 as a relief fund and the police and the charity organizations coöperated in caring for the needy. Commission merchants and warehouse owners along the river front suffered heavy losses. In some buildings the water was up to the second stories. The Panhandle and the Louisville & Nashville freight houses were half submerged. The Grand Central Station was put out of commission when the 54-ft. stage was crossed on the 11th, and all trains to that station had to be rerouted into the city.

The highest stage, 62.2 ft., was not reached until Jan. 15. This is 12.2 ft. above the danger line, and 8.9 ft. below the record stage of 1884. The river fell very slowly, and on the 20th, 10 days after it had crossed the danger line of 50 ft., it was still 51.6 ft. It is estimated that the damage from this flood at Cincinnati will be nearly $2,000,000.

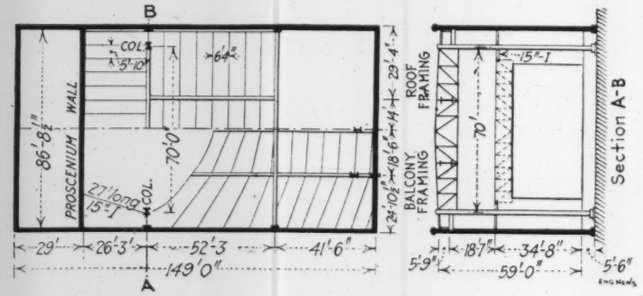
Similar conditions obtained in practically every Ohio River city and town. In the outlying districts, many hundred square miles of bottom lands were flooded from 3 to 20 ft. deep and in numerous cases livestock was cut off and drowned. The total loss along the Ohio Valley will foot up to many million dollars.

Failure of a Theater Building, New York City

The larger part of the roof of the Orpheum Theater, a large vaudeville house under construction at 3d Ave. and 87th St., New York City, collapsed on Jan. 22, at about 5:20 p.m., just after some 200 workmen had left the interior of the building. The falling roof carried down with it into the cellar the cantilevered balcony and the orchestra floor, completely wrecking the auditorium of the theater, but fortunately there was no one in that portion of the building at the time, so no one was injured in the collapse.

The accompanying sketch will give some idea of the construction of the building and the nature of the collapse. The main portion of the theater, 87x149 ft. in plan, comprises the stage and auditorium. There is a main floor carried on columns from the cellar, a balcony mainly carried on cantilever trusses extending back into a rear truss and columns, and a reinforced-concrete slab roof spanning beams between trusses, which in turn frame into two main transverse trusses. The stage is separated from the auditorium by a brick proscenium wall with the proscenium opening formed by a transverse truss resting on the brick wall.

It will be noted from the roof-framing plan on the cut that the load of the short-span concrete slabs is carried through beams and trusses to two main trusses. One of these, at the rear of the auditorium, about 87 ft. long, spans the entire width of the building and rests on brick pilasters built out from the side walls. The other, nearer the stage, was 70 ft. long and spanned between two steel columns set some 8 ft. in from the walls and extending up from the footings of the building. That portion of the roof between this latter truss and the stage was carried on the truss and on the proscenium wall.



Plans and Section of Theater

The 70-ft. truss is 8 ft. deep at the column and 9 ft. 3 in. at the center, with a horizontal bottom chord. The columns on which it rested are of I-section, made up of two 6x4x$\frac{7}{16}$-in. angles with a 12x$\frac{3}{8}$-in. center plate. They are 64 ft. 6 in. in total length and were designed to be braced, as shown, at the stage level, at the level of the top of the proscenium truss and opposite the 70-ft. truss. The bracing at the proscenium truss consisted of a light beam to the adjacent brick wall and a 15-in. I-beam extending over the 27-ft. distance to the proscenium wall. The connection of the balcony fascia girder to the column was very light and of no structural value as a stiffener. The least radius of gyration of the column is about 2½ in., so that assuming a rigid bracing the greatest value of $\frac{l}{r}$ is about 165; with the proscenium truss brace omitted, $\frac{l}{r}$ for the column would reach 256. The footings of the columns and walls were on concrete base to solid rock.

At the time of the accident all of the brickwork had been completed, the steelwork was all in with the exception of some minor framing around the stage boxes, and the concrete roof had all been completed. The workmen were engaged in the plastering and other decoration of the auditorium. No eye witness has come forward as yet with an account of the accident, so what occurred can only be inferred from examination of the ruins.

The collapsed portion embraces all of the area between the proscenium wall and the 87-ft. truss and within that area the destruction is complete. The four walls are still standing apparently undamaged, the 87-ft. truss is slightly twisted and at the connection to the longitudinal trusses its vertical posts are torn out, but it is still in place. The proscenium wall was bulged to such an extent that the building department required its removal. The two columns are down, lying in the auditorium, but that space is entirely covered as with a blanket by the concrete and plaster of the roof and balcony, so that the precise position and condition of the steelwork cannot be determined until after the removal of the débris.

In view of the condition of the building it is difficult to form an opinion as to the cause of the collapse. The building is to be carefully inspected by official and private engineers during the uncovering of the wreckage; after this inspection has been made and the accordance between design and construction noted, a more complete study of the accident can be made.

The building was designed by Thomas W. Lamb, Architect, for Loew's Theater Enterprises. The steelwork was designed and built by the National Bridge Works. The general contract was held by Fleischman Bros. All these parties are of New York City. The theater was one of a number of similar ones being built in New York for the same company and designed by the same architect. It was to have a capacity of over 2000.

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Partial Failure of Reservoir Lining, Johnson City, Tenn.

By D. R. Beeson*

A portion of the concrete lining of a new reservoir just put in service for the water-supply of Johnson City, Tenn., blew out on Jan. 10 and allowed the contents of the reservoir to escape. No one was injured in the accident nor was any property other than the reservoir proper damaged by the outflowing water.

The new reservoir is to be used for emergency storage, being a part of the new city water-supply system from a set of springs 13 miles away from town. It is located on a ridge south of the city at an elevation about 145 ft. higher than the general level of the residence section of the city. As shown in Fig. 1, it is 200 ft. square on top and 20 ft. deep, with sloping sides on a 1¼ to 1 slope. When full to the overflow, 1 ft. below the rim, it has a capacity of 4,000,000 gal. The bottom and sides of the reservoir were lined with concrete, 8 in. thick, reinforced with ⅝-in. twisted rods 18 in. c. to c. both ways. The engineers say that the lining was for the purpose of

*Johnson City, Tenn.

waterproofing only and not figured to resist any strain due to water pressure, and that the reinforcement was to prevent expansion cracks and not to add strength to the concrete. The lining was not waterproofed. Where the side lining joined the floor and in other places where new

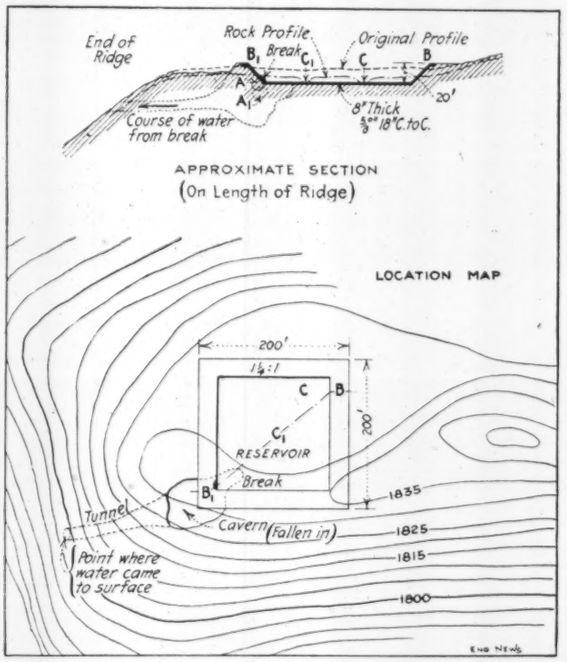

FIG. 1. PLAN AND SECTION THROUGH RESERVOIR

concrete was joined to old in the course of construction, there was no effort made to secure a bond between the two except by the reinforcing. Consequently, in many places, these joints show very pronounced cracks.

The concrete was mixed 1 : 2 : 4 with a standard cement, good coarse sand and broken limestone. The limestone was secured from the excavation for the reservoir. At the corner where the break occurred the concrete seems good and not affcted by the freezing weather in which some of it was laid. The thickness of the concrete at this point is about 7 in. The reinforcing had been lap-jointed here and all five inclined rods shown in the break were lapped opposite each other horizontally. None of the reinforcing was broken, the ends being pulled apart at the joints. Forms for the sloping sides were of wood, spiked to stakes driven into the ground. These stakes were supposed to be driven down beyond the concrete as the work progressed, but some of them, at least, were left in the concrete and may be seen projecting out of the slab on the under side of the break.

Johnson City is located in the eastern part of Tennessee on a formation named, by the U. S. Geological Survey, the Knox Dolomite. The rock of this formation is a blue limestone and weathers very easily on account of the solubility of its component materials and the whole area covered by it has been considerably bent and shaken in prehistoric times, so that the rocks are much broken and characterized by many fissures and caverns. The soil is the red clay of eastern Tennessee and western Virginia, which washes and slides very readily.

The floor of the reservoir was built for the most part on rock bottom, of the sort described above. At the corner of the reservoir, where the break occurred, the rock seemed to run out abruptly and the construction was on natural earth. The rim of the reservoir is above natural grade, making it necessary to back the sides with an earth fill of height varying from nothing to about 6 or 8 ft. A rock profile is very difficult to determine in this formation, as the strata are characterized by many projecting points and large boulders. At the side of the reservoir marked *B* (Fig. 1) the rock cut was deep enough to place the floor on fairly solid rock, but toward the broken corner it was laid on earth as before mentioned. In excavating for this corner a point of rock appeared that had to be blasted off. This was afterward proved to be a boulder of about 8 cu.yd., and after the accident was found to have dropped about 8 ft. from its original position to a ledge of limestone underneath. In Fig. 1 the position of this boulder before and after the break is shown at *A* and *A1*. Two caverns, *C* and *C1* (Fig. 1), in the limestone rock were discovered in the course of excavating for the floor. These were filled with concrete, 22 cu.yd. being used therefor. No cavern was apparent under the corner which broke.

Water from the city main was turned into the reservoir at 11:30 a.m. on Jan. 8, 1912, and the break occurred at 2 a.m., Jan. 10. The reservoir had filled to a depth of 17 ft. Instead of discharging at the surface of the ground immediately outside the break, the water took

FIG. 2. VIEW OF RESERVOIR, SHOWING BREAK IN FAR CORNER

FIG. 3. NEAR VIEW OF BREAK TAKEN EIGHT DAYS AFTER OCCURRENCE
(Cracks in concrete lining appeared after the initial break)

an underground course and came to the surface nearly 200 ft. away, as shown on Fig. 1, on the slope or nose of the ridge. After the accident there was a hole or cavern directly under the break extending 35 ft. straight down and running back 30 ft. under the floor of the reservoir. The surface had fallen in pretty badly for a space about 30 ft. each way at this corner of the reservoir. The hole showed earth bottom so it is impossible to state at this time the distance down to solid rock. Approximate outline of this hole or cavern is shown on Fig. 1. This hole may have been an open cavern before the accident or it may have been filled with earth. Ledges of rock can be seen at both sides of it about 10 or 15 ft. below floor level, but none is apparent back under the floor or in the channel taken by the water. The rock visible in this hole does not show the lines of stratification, being very much weathered, but a railroad cut near-by shows the strata pitching about 50° from the horizontal.

The photographs illustrating this article were taken eight days after the accident and show the concrete at the broken corner sagged down by its own weight and badly cracked, but the day after the trouble occurred the concrete was in place as built and showed no strain or tension cracks whatever, although the earth had all been washed from under it. The break in the concrete, 8 ft. wide by 6 ft. high, was the only sign of failure in the lining.

As to the probable cause of the break, it seems evident that the reservoir leaked through the bad joint in the concrete, where the side joins the floor, and that the leaking water made for itself a tunnel in the clay soil coming to the surface. The pressure of the water on the unsupported concrete lining over the reservoir end of this tunnel probably broke the lining and gave egress to the water stored in the reservoir. The cavern under the broken corner was probably excavated by the big stream of water after the concrete broke, though some part of it may have been there before. There are no proofs as yet discovered that there was a cavern at this point in the natural formation, and if there was it must have been well below the floor of the reservoir, or the boulder mentioned above could not have remained in place over it.

No plan for repairing the reservoir has as yet been adopted, but the engineering firm that had the work in charge has recommended that the hole or cavern under the break be filled and the damaged corner rebuilt where it was originally.

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The New Subways under construction and projected in New York City on a coöperative contract between the city and street railway corporations of New York and Brooklyn, may be definitely assured to the city by the time this issue of "Engineering News" reaches our readers, or may be indefinitely postponed. It is impossible at the time of going to press to predict which result will occur.

There are undoubtedly honest differences of opinion between those who have given most careful study to the subject as to whether these contracts for the dual subway should be signed by the city authorities. On the other hand the majority of business men interested in the city's welfare who have given careful study to the subject appear to be convinced that the pending contracts are as good as the city could hope to secure, and that under existing conditions it is of great importance to the city that the contracts should be concluded.

A Building Collapse occurred at McKinney, Tex., on Jan. 23, followed by a fire, and resulted in the loss of eight lives. About 15 other persons were injured. The killed and injured were in a four-story building occupied as a department store. An adjoining building used for storage purposes collapsed first, according to press accounts, and caused the cave-in of the first-mentioned structure.

A Rear-end Collision on the 3rd Ave. "L," New York City, on Jan. 25, involved the death of one man and injury to 17 other persons. The first train was stopped between stations by a track repair gang and was struck at almost full speed by the second train, which was following it closely. The back end of the last car in the stationary train and the front end of the first car in the moving train were telescoped and lifted from the tracks, projecting several feet out over the street from the "L" structure. A short-circuit in the wrecked motorman's box on the rear train started a fire that further damaged the two cars. The accident occurred at about 3:30 p.m., and held up traffic on the street cars until 6:30 p.m., and on the elevated line until 8 p.m.

Portland Cement Production in 1912 is estimated by the U. S. Geological Survey to be approximately 81,941,998 bbl., an estimate which is believed to be within 1½% of the correct figure. This is an increase of 4.3% over the 78,528,637 bbl. production in 1911.

Nine Bids for a Mechanical Filtration Plant to treat the Croton water supply, New York City, were received on Jan. 23. The bids ranged from $5,672,145 to $6,752,500 (see p. 48 of "Construction News" section for details). No award has yet been made.

The Biggest Battleship Afloat was launched in England, at Newcastle-on-Tyne, on Jan. 22. This boat is the Brazilian superdreadnaught "Rio de Janeiro," having a displacement of 27,500 tons and an armament of fourteen 12-in. and twenty 6-in. guns. She is designed for a speed of 22 knots an hour.

A battleship of equal displacement is building for the United States at the Fore River Yards, Quincy, Mass., and will be known as the "Nevada." Another battleship of 31,500 tons displacement, the "Pennsylvania," is projected, but no work has started on her.

The Awarding of Medals by the American Museum of Safety took place on the evening of Jan. 22, at the United Engineering Societies Building, in New York City. The "Scientific American Medal" for the most efficient safety device invented in the past three years was awarded to F. F. Morris, of the Draeger Oxygen Apparatus Co., makers of the pulmotor. The "Traveler's Medal" went to the New York Edison Co., for work in the line of safeguarding their power-plant employees, and was received by John W. Leib for the company. Frederick Patterson received for the National Cash Register Co., the "Seaman Medal," for the promotion of industrial hygiene and sanitation and the mitigation of occupational diseases.

The feature of the evening was the awarding to Thomas A. Edison of the "Rathenau Medal," recently placed at the Museum's disposal by the Allgemeine Electricitaäts Gesellschaft, of Berlin. This is the first annual award of the medal and was for the invention of a safety electric mine lamp. Mrs. Edison received the medal because of the inventor's enforced absence.

Following the several awards announcement was made of the establishment of an E. H. Harriman Memorial Medal to be awarded annually to the American steam railway making the best record in accident prevention and industrial hygiene, affecting both the public and its own personnel.

PERSONALS

Dr. C. E. Dutton has been appointed Health Commissioner of Minneapolis, Minn., succeeding Dr. P. M. Hall.

Mr. Herman F. Doeleman has opened offices at 614 American Bldg., Baltimore, Md., as a consulting structural engineer in steel and concrete.

Mr. J. O. Ely, formerly Assistant Engineer of the Louisville & Nashville R.R., at Knoxville, Tenn., has been appointed Roadmaster of the Lexington & Eastern division.

Mr. E. H. Fitzhugh has resigned as President of the Central Vermont R.R., at Montreal, Que. He is succeeded by Mr. E. J. Chamberlin, President of the Grand Trunk Ry., of which the Central Vermont R.R. is a subsidiary.

Mr. M. T. Clements, of Superior, Wis., has been appointed Engineer in charge of grade separation, Northern Pacific Ry., at Spokane, Wash. The work will require an expenditure of $3,500,000 and is to be completed in three years.

Mr. F. L. C. Bond, Assoc. M. Can. Soc. C. E., Resident Engineer, Eastern division of the Grand Trunk Ry., Montreal, Que., has been promoted to be Division Engineer of the Eastern division. His headquarters will remain at Montreal.

Mr. E. F. McCrea, formerly Division Engineer of the Pennsylvania R.R. Lines West of Pittsburgh, at Toledo, Ohio, has

been transferred to a similar position on the Cleveland & Pittsburgh division, with headquarters at Cleveland, Ohio.

Mr. E. G. Johnston, formerly Assistant Engineer, Pennsylvania R.R. Lines West of Pittsburgh, Southwest system, at Indianapolis, Ind., has been promoted to be Assistant Division Engineer of the Eastern division of the Northwest system, at Pittsburgh, Penn.

Mr. Philip Lacey, City Engineer of Bessemer, Ala., has resigned to become a member of the staff of Mr. James N. Hazlehurst, M. Am. Soc. C. E., Consulting Engineer, of Atlanta, Ga. Mr. Lacey will have charge of paving and sewer work in Tampa, Fla.

Col. George W. Goethals, M. Am. Soc. C. E., Chairman and Chief Engineer of the Isthmian Canal Commission, was the guest of honor at a dinner given by the Lehigh University Club of New York, at the Hotel Astor, Jan. 27. Besides members of the club a number of prominent engineers were invited guests.

Mr. Ralph Budd, whose appointment as Assistant to the President of the Great Northern Ry. was noted in our issue of Jan. 2, will have charge of the construction of the new Minneapolis, Minn., passenger station of the Great Northern Ry., and of the extensive terminal improvements underway in St. Paul and Minneapolis.

Mr. Mott Sawyer, formerly Superintendent of the Bellingham Bay & British Columbia R.R., has been appointed Superintendent of the Columbia division of the Chicago, Milwaukee & St. Paul Ry., at Malden, Wash. The Bellingham Bay & British Columbia R.R. was recently purchased by the Chicago, Milwaukee & St. Paul Ry.

Mr. Julian B. Beaty, Secretary to the Borough President, Borough of Manhattan, New York City, has been appointed Superintendent of Public Buildings of the Borough of Manhattan at a salary of $5000 per annum. Mr. Beaty was at one time secretary to ex-President Cleveland, and for a short time, to Governor Woodrow Wilson, of New Jersey, President-elect.

Mr. Arthur B. Recknagle, of the United States Forest Service, in charge of District No. 3, New Mexico, has been appointed Professor of Forestry at Cornell University. Prof. Recknagle is a native of Brooklyn, N. Y., and a graduate of Yale University and of the Forestry School at Yale, class of 1906. He has served continuously in the U. S. Forest Service with the exception of a year spent in European study.

Dr. Alvah H. Doty, former Health Officer of the Port of New York, has been appointed Medical Director of the Employees' Benefit Fund Committee of the American Telephone & Telegraph Co., the Western Union Telegraph Co., and the Western Electric Co. It will be among the Medical Director's chief duties to look after the sanitary conditions in the offices and shops of the three companies and to instruct employees in hygiene and sanitation.

Mr. George G. Powell, Assoc. M. Can. Soc. C. E., Deputy City Engineer of Toronto, Ont., has declined an offer to become Public Works Commissioner of Prince Albert, Sask., at a salary of $6000 per annum. Mr. Powell's salary at Toronto is $4000 per annum. The recent City Engineer of Toronto, Mr. C. H. Rust, M. Can. Soc. C. E., resigned to accept a similar position at Victoria, B. C., at a salary of $6500 per annum, as noted in our issue of May 2, 1912.

Mr. Alfred K. Chittenden, Forester of the United States Indian Service, Department of the Interior, has been appointed Director of the Engineering Experiment Station and Lecturer on timber and timber resources at the College of Engineering of the University of Illinois. Mr. Chittenden is a native of New Haven, Conn., and a graduate of Sheffield Scientific School, Yale University, class of 1900, and of the Yale Forestry School in 1902. After a year's study in Europe he entered the U. S. Forest Service in 1903. In 1911 he was appointed Forester in the Indian Service.

Mr. Frank F. Fowle, M. Am. Inst. E. E., has resigned as Associate Editor of the "Electrical World" to resume his practice as a consulting electrical engineer, with offices at 68 Maiden Lane, New York City. Mr. Fowle graduated in electrical engineering at the Massachusetts Institute of Technology in 1899. For a number of years he was with the engineering and railway departments of the American Telephone & Telegraph Co., in New York City, and with the operating department of the same company in Chicago, Ill. From 1908 to 1912 he was a consulting engineer with offices in Chicago, Ill.

Mr. John B. Dickson, formerly General Agent of the Erie R.R., at Chicago, Ill., has been promoted to be Superintendent of the New York division, succeeding Mr. R. S. Parsons, M. Am. Soc. C. E., promoted as noted in our issue of Jan. 16. Mr. Dickson entered the railway service in 1882, at the age of 20 years, in the maintenance-of-way department of the Cleveland & Pittsburgh division of the Pennsylvania R.R. Lines West of Pittsburgh. In 1887 he was promoted to be Supervisor. In 1893 he was appointed Roadmaster of the Galena division of the Chicago & Northwestern Ry. After 10 years' service with this railway he was appointed Assistant Engineer of Maintenance-of-Way of the Baltimore & Ohio R.R. Three years later he was promoted to Chief Engineer of Maintenance-of-Way, which position he held until he entered the operating department of the Erie R.R. a few years ago.

Mr. William B. Wood, recently Superintendent of the Cleveland & Pittsburgh division of the Pennsylvania R.R., at Cleveland, Ohio, has been promoted to be Superintendent of the Eastern division of the Northwest system of the Pennsylvania R.R. Lines West of Pittsburgh, with headquarters at Allegheny, Penn. Mr. Wood is a graduate of Sheffield Scientific School, Yale University, class of 1897, and began his railway work in the chief engineer's office of the Pittsburgh, Cincinnati, Chicago & St. Louis R.R., in October, 1897. Two years later he was promoted to be Assistant Engineer of the Cleveland & Pittsburgh division of the Pennsylvania R.R. Lines West of Pittsburgh, and on Jan. 1, 1901, he became Engineer of Maintenance-of-Way of the Cincinnati & Muskingum Valley R.R. A short time later he returned to the Cleveland & Pittsburgh division in the same capacity and after two years' service was transferred to the operating department as Superintendent of the Cleveland, Akron & Cincinnati Ry. He was made Superintendent of the Cleveland & Pittsburgh Division about a year ago.

Mr. W. D. Faucette, whose appointment as Chief Engineer of the Seaboard Air Line Ry. was noted in our issue of Jan. 2, is a graduate of the Agricultural and Mechanical College of North Carolina. He entered the railway service in 1901 as an engineering inspector with the Seaboard Air Line Ry., at Savannah, Ga., and in 1903 was promoted to be Assistant Engineer at Savannah. The following year he was placed in charge of the Assistant Engineer's office at Savannah, having supervision of the engineering work south and west of Columbia, S. C. In 1906 Mr. Faucette was promoted to be Assistant Engineer attached to the Chief Engineer's Office at Portsmouth, Va. Four years later he went to New York City as Chief Clerk to the President. In September, 1912, he returned to Norfolk, Va., as Chief Clerk to the new President, Mr. W. J. Harahan, M. Am. Soc. C. E., who had been Vice-President and Chief Engineer of the Erie R.R. Mr. Faucette's recent appointment as Chief Engineer of the Seaboard Air Line Ry. makes him one of the youngest chief engineers of a great railway system.

Mr. A. R. Whaley, General Superintendent of the Electric Division of the New York Central & Hudson River R.R., New York City, has been elected Vice-President of the New York, New Haven & Hartford R.R., in charge of operation, succeeding Mr. H. J. Horn, who will give his entire attention to the operating department of the Boston & Maine R.R., of which he is also Vice-President. Mr. Whaley was born at Rock Island, Ill., in 1861. In 1877, at 16 years of age, he became a freight brakeman on the Providence & Worcester R.R. He passed through the various grades of baggageman, conductor, stationmaster, trainmaster, yardmaster and general yardmaster until 1899, when he was promoted to be Superintendent of the Worcester division of the New York, New Haven & Hartford R.R., which had absorbed the Providence & Worcester R.R. Later he was made Superintendent of the railway's most important division, with headquarters in New York City. In 1907, Mr. Whaley became General Superintendent of the electric zone of the New York Central & Hudson River R.R. and Manager of the Grand Central terminal. Under his supervision the train service to and from the Grand Central has been continued uninterruptedly during the entire reconstruction of the tracks, terminal and station building. It has been said that for the past six years he has supervised the traffic of 750 trains a day with an average delay of less than a minute a train.

OBITUARY

Michael Horan, City Engineer of Peru, Ind., died in that city, Jan. 18. For a number of years he also served as County Surveyor.

John MacGregor, Assoc. Am. Soc. C. E., Engineer of the United States Fidelity & Guaranty Co., Baltimore, Md., died in that city, Jan. 21.